ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. 62. No. 6. 220 Broadway, New York, August 5, 1909.

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A 259-Ft. Concrete Arch Bridge in Switzerland.

A brief note in our issue of Dec. 3, 1908, reported that a new holder of the title of largest concrete arch in the world had just arisen, in the Sitter highway bridge, Canton Appenzell, Switzerland. Descriptions of this interesting structure, one by Prof. E. Mörsch, its designer, published in the "Schweizerische Bauzeitung" Feb. 13 to March 6, 1909, and another by Mr. E. Froté, in the "Génie Civil" of March 13, 1909, enable us to give the chief details of design and erection. Until the 280-ft. arch at Cleveland, O., and the 281-ft. arch at Spokane, Wash., are completed the Sitter bridge will be the largest concrete arch.

The bridge carries the highway between the villages of Stein and Teufen, near the latter, over the gorge of the upper Sitter River. An iron bridge was built here in 1856, but in late years this had gotten into very bad condition. In the course of planning to replace it, a better site was found several hundred feet downstream, and the new bridge was projected to suit this location, with a roadway level about 50 ft. higher than that of the old bridge, reducing the gradients and length of the approach road. Comparative designs and estimates for a steel bridge and a reinforced-concrete arch showed the latter to cost so little more than the other that the authorities decided for the concrete structure.

GENERAL VIEW OF SITTER ARCH BRIDGE, NEARLY COMPLETED.

The valley at the site of the bridge is sharply V-shaped in cross-section. The roadway elevation selected is 216 ft. above the brook. Placing the abutments about halfway up the side slopes gave an arch of 259.1 ft. (79 m.) clear span and 86.9 ft. (26.5 m.) soffit rise. For the end portions of the bridge, groups of smaller arches spanning 33.6 ft. (10.25 m.) in the clear were adopted. The outline elevation Fig 2 exhibits all the general features of the structure as designed and built, except as to width, for which see the cross-section in Fig. 3. The deck is unusually narrow, being only 22½ ft. between railings, including two 24-in. footwalks.

CENTRAL SPAN.—An arch so narrow obviously demanded a solid, i. e., undivided, arch-ring. Even so it was thought proper to increase the stability by battering the faces of the ring. The width of ring is 21.4 ft. (6.5 m.) at the crown and 24.6 ft. (7.5 m.) at the skewbacks, the vertical batter of the plane of the end curves of the soffit being made 1:54⅔. The outer line of the arch departs from this plane, since normal sections of the ring were made rectangular. The structure is of the open-spandrel type, i. e., the roadway is a slab which rests on columns footing on the arch ring.

The arch curve was chosen to fit the dead-load pressure line; it had to be found by cut-and-try procedure, of course, but Prof. Mörsch's article gives the impression that the curve first assumed required correction only once, the result then checking perfectly. He does not give the ordinates of the final curve, but one may infer that it does not depart much from a catenary.

As regards the action of live-load, the arch was assumed to be a fully elastic hingeless arch. The ring was made 49 ins. (1.20 m.) thick at the crown and 84 ins. (2.13 m.) thick at the skewbacks.

The following loads, etc., were the basis of the figuring:

Uniform live-load, 92 lbs. per sq. ft.

Concentrated live-load, 22-ton road-roller.

Temperature variation, ± 36° F.

The center-to-center dimensions used in the computations were: span 79.64 m., rise 25.5 m.

The computed outer-fiber stresses at various sections are given in the little table below. It will be noted that the dead-load stresses are not the same in upper and lower fiber, although it is said above that the curve of the neutral line was adjusted to the dead-load pressure line. The discrepancy results from the fact that the pressure line (and hence the curve of the neutral line) was laid out as usual on the basis of moments only, whereas the analytical calculation includes the effect of the shortening caused by the axial compression. The result of the latter is to increase the upper and decrease the lower fiber compressions over the central half of the span, while in the end quarters it has the reverse effect, increasing the compression in the lower fiber and decreasing the compression in the upper fiber.

The greatest stress shown by the table is 444 lbs. per sq. in., a very moderate compression for first-class concrete such as must be used in a structure of this kind. There are no tensile stresses under any conditions, theoretically; therefore the steel reinforcement which was put into the ring has no specific duty but serves only as extra security.

The reinforcement is shown quite fully in Fig. 3. The flange rods are all 1¼-in. rounds. In the bottom flange they vary from 10 at the springing-line to 18 at the crown, in the top flange from 18 at springing to 10 at crown, distributed over the width of the ring. Joints are lapped 39 ins. Transverse distributing rods are placed in both upper and lower flanges on a uniform spacing of 20 ins. throughout the length of the arch; they are ⅞-in. rounds except under the columns, where 5 rods in the bottom flange and 4 rods in the top flange are increased to 11/16-in. diameter. Radial stirrup looping of 5/16-in. rod ties the main rods together halfway between the distributing rods.

The reinforcement of the columns is simple rod and tie work, without hooping. The columns have a rather low stress, and their only feature of interest is that the columns of the tallest bent are unusually slender, being about 53 ft. high

LOAD AND TEMPERATURE STRESSES IN 259-FT. ARCH SPAN.

Stresses in Lbs. Per Sq. In.

Section	Dead-Load, Compress.	Live-Load, Compress.	Live-Load, Tens.	Temperature, Either Stress.	Total Max.	Total Min.
At Crown:						
Top Fiber	+230	+112	−51	±82	+444	+117
Bottom Fiber	+197	+68	−91	±88	+353	+18
31.3 Ft. from Crown.						
Top Fiber	+240	+129	−95	±57	+426	+88
Bottom Fiber	+202	+115	−111	±65	+382	+26
73.6 Ft. from Crown.						
Top Fiber	+206	+70	−75	±20	+296	+111
Bottom Fiber	+219	+102	−61	±17	+338	+141
105.2 Ft. from Crown.						
Top Fiber	+192	+55	−47	±68	+315	+77
Bottom Fiber	+233	+65	−41	±65	+363	+127
At Skewback:						
Top Fiber	+181	+140	−87	±88	+409	+6
Bottom Fiber	+234	+102	−126	±85	+421	+23

and only 20 ins. square, a length-ratio of about 100. This bent has transverse strut bracing but no longitudinal bracing.

The floor consists of a flat reinforced plate spanning about 74 ins. between stringers. The stringers connect directly to the columns, and the members which occupy the place of floor-beams serve only as bracing. The plate is thinnest along the center line of the bridge, because its top surface is sloped down toward a longitudinal drain in the middle. Its thickness here is 8 ins., against 10 ins. at the edges. The reinforcement of plate and stringers follows familiar types and needs no special notice.

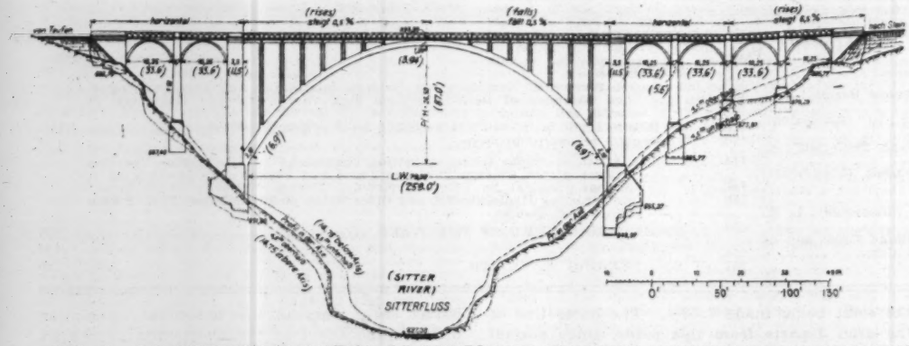


FIG. 2. DOWNSTREAM ELEVATION OF REINFORCED-CONCRETE HIGHWAY BRIDGE OVER THE SITTER, NEAR TEUFEN, CANTON APPENZELL, SWITZERLAND.

A noteworthy detail of the main span is the means provided to allow for expansion of the floor. Where the roadway plate joins the piers over the arch abutments, a connection of the elastic-membrane type is used instead of the common sliding support. The elastic-membrane here is represented by a 10-in. reinforced-concrete wall 40 ft. high (Fig. 3), whose base is integral with the pier while its top is integral with the floor-slab and stringers. An open space of 5 ins. separates this wall from the body of the pier; this width was needed to get a form in, rather than for expansion, as the maximum movement will be less than ½-in. either side of the normal position. The wall is slender enough to stand a deflection of about 1-in. without overstressing.

SIDE SPANS.—The six subsidiary arches, clear span 33.6 ft., were treated like the main arch in respect to determination of shape, i. e., they were adjusted to the pressure line for dead-load. But instead of having open spandrels and therefore definite amount and direction of loading, they carry a solid fill. The fill was made of lean (1:16) concrete, in place of the more customary earth fill, so that there may be great doubt as to whether and how the arch rings will carry any large share of the roadway load. This fill concrete is divided by construction joints in continuation of the pier faces (see Fig. 4). The part over the pier was placed first, then its sides painted with a tar compound, and then the spandrel filling placed against these surfaces.

These arches have a soffit rise of 15.2 ft., a crown thickness of 14 ins., and top and bottom reinforcement of 9/16-in. rods 8 ins. apart, with 5/16-in. transverse rods 10 ins. apart, tied together by 5/16-in. stirrups 16 ins. apart. At the piers the reinforcement is doubled, to ensure fixity of the ends of the arch. As the thrust of the small arch next the main spans is an unbalanced thrust high up on the pier, the pier is reinforced on its landward side by 30 1-in. vertical tension rods, extending about 40 ft. above the base of the pier.

ABUTMENTS.—The abutments of the approaches (Fig. 4) are of hollow (cellular) type, to eliminate earth thrust, similar to those of the Piney Branch bridge in Washington, D. C., described in Engineering News of Nov. 16, 1905, pp. 510-512.

ROADWAY DETAILS.—The roadway pavement is a crowned Telford, as the cross-section in Fig. 3 shows. This rests on a bed of concrete made without sand so as to be porous and permit the percolating water to pass to the drain. The top of the floorslab is covered with sheet asphalt as a waterproofing, which drains to a longitudinal perforated steel drainage channel on the center line by virtue of the transverse slope of the top of the slab. The concrete base course of the pavement rests directly on the waterproofing. The roadway rises from either end of the main span toward the center on a ½% grade, which gives the drain a slope for discharging into spouts at the ends of the span.

On the approach spans the fill concrete is similarly covered with waterproofing, but this is pitched downward toward the center of each span, where a downspout passes through the ring concrete.

The sidewalks are composed of separately molded slabs, resting on the floorslab and lapping over the edge of the waterproofing. They are of such thickness as to give the desired elevation for the footwalk surface, and in their molding edge is molded in a re-entrant angle to form the gutter, whose curb edge is strengthened by an imbedded angle-iron.

The balustrade, molded in place, is of commendably simple design. It is reinforced as shown in Fig. 5. A wide pilaster occurs over each line of roadway columns, and there the balustrade is cut by an expansion-joint made by painting the edges of the pilaster with tar before molding the adjacent panels against it.

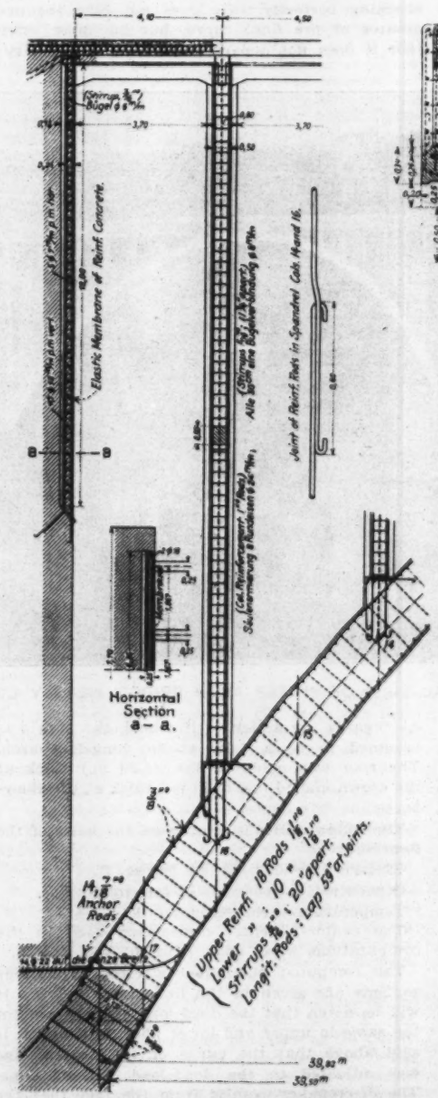
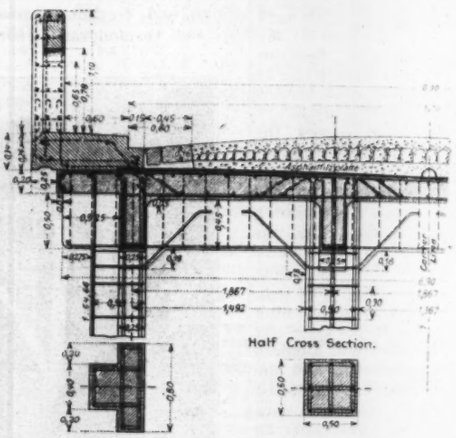

Elastic Membrane of Reinf. Concrete.
Joint of Reinf. Rods in Spandrel Cab Hand lit.
Horizontal Section a – a.
Upper Reinf. 18 Rods 16
Lower " 10 " 20" apart.
Stirrups
Longit. Rods: Lap 39" or Joints.
14 Anchor Rods

FIG. 3. DETAILS OF MAIN SPAN OF SITTER BRIDGE.

Construction.

The piers and abutments have good rock foundations near the surface, and the centering of the main arch also footed on rock.

CENTERING.—The centering for the large span was designed as simple trestle-bent framing. It is spread considerably by batter braces, as it had to have sufficient stability to stand through the winter without load, concreting being started in spring of 1908. A horizontal division near the springing-line separates the upper part or centering frame proper from the lower part which is in effect a simple trestle. Sandboxes are set in this division plane, for lowering the upper frame after the arch was keyed up. The view Fig. 7, showing the completed



centering, and the elevation Fig. 8 of the upper portion, will suffice to explain the general arrangement.

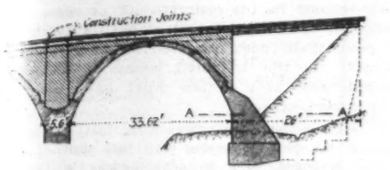
The upper frame, during the concreting operations, is exposed to inward thrust from the haunch sections of the arch ring, because of the method of supporting the successive sections of concrete by strutting across the open key spaces (Fig. 11). While the thrusts on one side balance those on the other side, so long as the concrete is carried up symmetrically, it was thought better to transfer them back into the abutments by means of anchor ties, thus eliminating compressions in the horizontal members of the frame. The attachment of these ties is shown generally in Fig. 8, and more in detail in Figs. 9 and 10.

The latter illustrations also show the style and proportions of the sand-boxes. The boxes themselves, 144 in number, are of steel, the plugs of wood. The joint was sealed with asphalt, but at the time of striking centers it was found that this had not succeeded in keeping the sand dry.

To reduce the cross-grain crushing at joints of the centering, hardwood and channel-iron corbel blocks were used extensively, of such proportions as to keep the cross-grain compressive stresses down to about 250 lbs. per sq. in. This precaution, together with excellent workmanship in erecting the timber-work, is credited with the surprising smallness of the settlement during the placing of the concrete, namely 1¼ ins. Even of this settlement some ⅝-in. is charged to

shr[illegible]age of the sills in drying out after the mo[illegible] weather of early spring.

CONCRETING.—The arch-ring was sectionalized as indicated in Fig. 8, the several sections being concreted in the order as there numbered. The small key sections 9 to 17 were filled last; the main sections 1 to 8 gave practically the



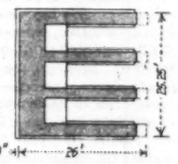


Fig. 4.
Cellular Abutment of Approach.

maximum load to the centering, uniformly distributed, so that the distorting tendency during keying would be minimized, and therefore the formation of cracks forestalled. The key sections, moreover, are located directly over the posts, and over the joints of the rim segments, so that the added weight of the key segments would have minimum distorting effect. The plan is reported to have worked very successfully; no cracks were found in the surfaces of the ring after completion.

The key spaces were spanned by timber strutting to support the concrete sections above. As the struts had to be removed, however, before the keys could be concreted, small concrete struts (Fig. 11) were poured as soon as the main sections were finished. These were of half the ring depth, and of one-fifth the ring width, so that two struts in each space gave a section one-fifth that of the ring. When they had set up (after 4 weeks), the timber struts were removed and then the space keyed up complete with concrete.

The concrete of arch-ring, columns, floor-slab and other reinforced work was of 1:2:4 mixture. Foundation concrete was of 1:4:8, and piers of 1:3½:7. The fill over the small arches was 1:16, with a 10-in. face layer of 1:12 mixture. Test cubes of the 1:2:4 mixture gave crushing strengths as follows: at 28 days, 4,350 lbs. per sq. in.; at 3 months, 5,600 lbs. per sq. in.; at 6 months, 6,350 lbs. per sq. in. These cubes were presumably rammed in the molds by the ham-

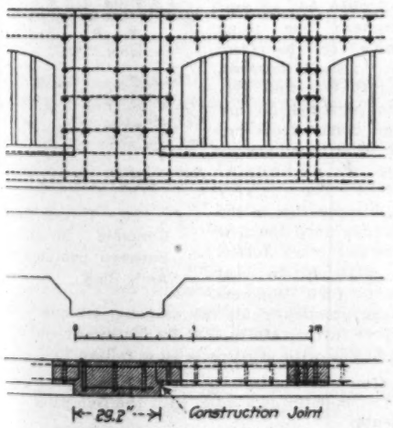


Fig. 5. Reinforcement of Concrete Balustrade.

mer machine, as is customary in European cement testing.

The reinforcing metal was coated with neat cement mortar before concrete was poured.

The back of the arch was coated with waterproofing, to shed rain-water.

Sand and gravel were obtained in the creek bed near the bridge site, and were brought by a narrow-gage track and a cableway to a screening, crushing and mixing plant at one end of the bridge. The concrete was carried by a longitudinal cableway, running directly over the bridge, to any desired point of the structure. The only disadvantage of this arrangement was that the capacity of the concrete cableway was inconveniently low.

STRIKING CENTERS.—At the time the centers were lowered, the structure was complete except for the macadam. In striking the center of the main span the procedure was as follows: Taking first the two middle rows of sand-boxes (six boxes each), a man being stationed at each box, the plugs were removed, about a half-pint of sand allowed to run out (or picked out), the plugs replaced, and the boxes then rapped with a stick of wood, this rapping producing the settlement; then the force proceeded similarly with the next row of boxes, and thus advancing step by step to the abutments the whole center was lowered uniformly. This first operation was figured for a settlement of about 1/12-in. Then the same operation was repeated in the identical order, and so on until the centering was free.

The final deflection at the crown was about 3/16-in. (5 mm.) at the crown, and zero at the

Fig. 6. View Along Roadway.

skewbacks. According to the calculations, this would correspond to a modulus of elasticity of 3,700,000 lbs. per sq. in. in the concrete.

The centers of the small arches were simple trussed arch frames resting on corbels set in the piers at the skewbacks. These centers compressed about ¼-in. during the concreting, and when centers were struck the deflection at crown was about 3/32-in.

TIME AND COST.—This structure was begun in March, 1907. Foundations and centers were completed by December. Concreting of the main arch was done between March 26 and May 16, 1908. Centers were struck Aug. 1, 1908, and the bridge was put into service three months later.

The total cost of the bridge was $80,000, of which the main span cost $18,000 and its centering $22,000. The total yardage of concrete was about 9,000, and the reinforcing steel amounted to 90 tons. The timber in the centering is given as 1,500 cu. m., which would figure out as 580 M. ft. B. M., and some 50 tons of bolts and other steelwork were required for connections.

The work was done by Froté, Westermann & Co. of Zürich as general contractor. R. Coray was subcontractor for the centering. Mr. A. Sutter was Resident Engineer for the cantonal government, with Prof. Mörsch in general charge.

Tests on the Resistance to Web Stresses of Reinforced-Concrete Beams.

The latest record of the reinforced-concrete beam tests at the University of Illinois has just been published as Bulletin No. 29 of the University of Illinois Engineering Experiment Station under the title of "Tests of Reinforced-Concrete Beams: Resistance to Web Stresses. Series of 1907 and 1908. By Arthur N. Talbot." The pamphlet is so lengthy (85 pp.) and so full of tables and diagrams that space will not permit a complete abstract here, but we give below a resumé of the general design of the tests and of the more important deductions.

Scope of Bulletin.

Tests of reinforced-concrete beams made in various laboratories have provided a considerable fund of information bearing on the part played by the tensile resistance of the longitudinal reinforcement and the compressive resistance of the concrete. The data on resistance to web stresses are less definite and less complete. In beams having a depth relatively large in comparison with their length, the resistance to web stresses becomes very important, and diagonal tension and bond stresses may control the strength of the beam. It was with a view of obtaining further information on web stresses and on the part taken by concrete, bent reinforcement, and stirrups in resisting web stresses that these series of tests were undertaken.

The tests were carried on during the years 1906-7 and 1907-8. Tests were made on (1) beams without web reinforcement, (2) beams with reinforcing bars bent up in various ways along the outer thirds of their length, and (3) beams with vertical U-shaped stirrups. Four span lengths were used. Various amounts of longitudinal reinforcement from 1% to 2.2% were used. Tests were made with concrete at different ages with a view of determining the effect of early removal of forms. Six mixtures of concrete were used, ranging from very lean to very rich. Compression tests of cubes and cross-bending tests of small concrete beams, called here control beams, were made with a view of determining whether a relation between the strength of the reinforced-concrete beams and the control pieces might be found which would be useful as a control test in building construction. In 1907, 117 beams were made and 71 beams in 1908. Of these 106 were without web reinforcement, 27 had the reinforcing bars bent up in one form or another, and 55 had stirrups for the web reinforcement. It was found impossible to carry out the tests exactly as planned, and the data of the tests do not furnish a basis for as definite conclusions as had been hoped. However, the tests throw light on the phenomena of web resistance and the results have a bearing on the principles of design.

The preliminary part of the bulletin is devoted to a theoretical study of the stresses in a reinforced-concrete beam, particularly to the web stresses. It is shown that in cases where the lower tension reinforcing is bent up at the ends of the beam, the distribution of web stresses is very uncertain, varying with the position of the rods, so that in the bulletin the values for shearing and bond stresses are calculated according to the simple formulas where the rods are in the bottom plane alone and the values so found are

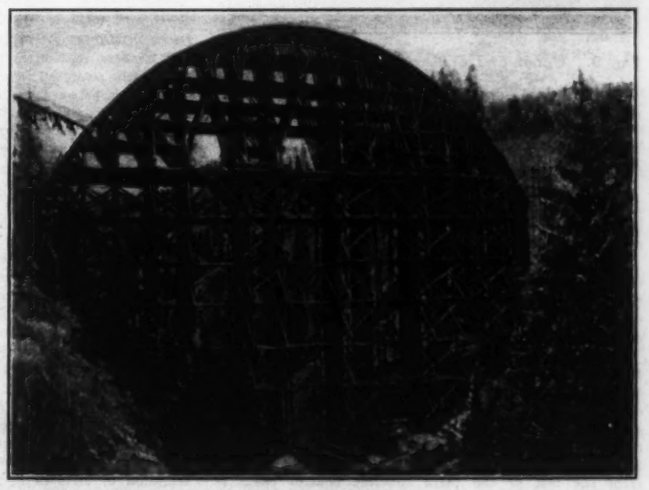


FIG. 7. VIEW OF CENTERING OF MAIN SPAN.

termed "nominal" and are only for the purposes of comparison. Where vertical stirrups are used it is assumed that all the shear is taken by the stirrups, though analysis of special cases shows this not to be exactly true.

In all the tests, the beams were 8 × 11 ins. in cross-section and varied in length from 6 to 12 ft. They were made out of standard materials by experienced concrete makers and stored in the laboratory for varying intervals. They were tested in a 200,000-lb. machine by loading at the third points.

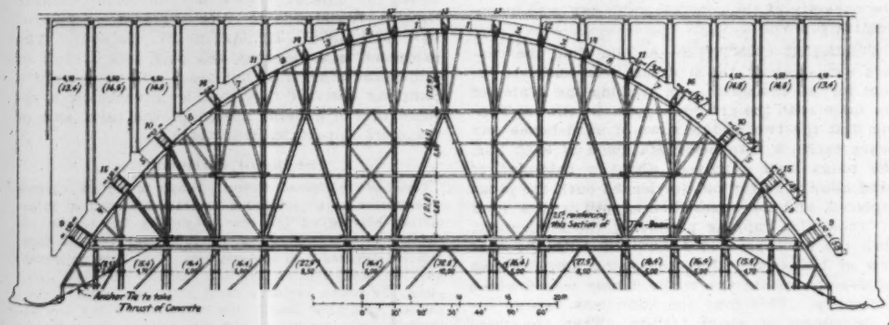


FIG. 8. SKETCH ELEVATION OF UPPER CENTERING FRAME OF MAIN ARCH, SHOWING ALSO SEQUENCE OF CONCRETING OF THE RING, SITTER ARCH.

Beams without Web Reinforcement.

Generally speaking the beams were arranged to give diagonal tension failure. On account of the simplicity of the reinforcement, the vertical shear and bond are easily computed and for this series of beams these two values are given as indicative of the amount of diagonal tension. These beams were planned to give information along the following lines:

EFFECT OF THE AMOUNT OF CEMENT.—It is evident from these tests that the addition of cement gives a considerable gain in resistance to diagonal tension and

Fig. 9. Upper End of Anchor Ties and Distributing Beams.

(The adjoining section of the tiebeam of the upper frame is made of two channels, as a tension member to transmit the reaction of the next set of batter posts to the anchors.)

that a rich concrete should be used in the web of reinforced-concrete beams which are subjected to any considerable amount of diagonal tension, especially if there is no metallic web reinforcement or the web reinforcement is not effective.

EFFECT OF AGE.—The results show considerable variation, as is to be expected. A rapid increase in web resistance with age may be noted at the earlier ages, and a slower change for the older beams. The lean concretes attain their strength slowly.

RELATION TO STRENGTH OF AUXILIARY TEST PIECES.—In building construction some auxiliary test may be used with advantage to check up the quality of the concrete placed in beams in which diagonal tension is the critical stress. The writer has suggested the form of flexure test piece here called the "control beam" for this purpose. The modulus of rupture determined from the test of the plain concrete control beam is representative of the tensile strength of the concrete and may be used as its measure, although it does not give the actual tensile strength of the concrete. The resistance of the beam to diagonal tension is dependent upon the tensile strength of the concrete. If the ratio which may be expected between the vertical shearing strength of the reinforced-concrete beam and the modulus of rupture of the control beam be established, this ratio and the flexural strength of the control beam may be used as a measure of the quality of the concrete to resist web stresses. This ratio may vary with different proportional dimensions of beams and with different amounts of cement, but if the ratios be determined for the various conditions, this method should be helpful as an aid to securing substantial construction. In the table given in the bulletin the average of this ratio of vertical shearing stress in the main beam to the modulus of rupture in the "control" beam is about 0.50.

EFFECT OF AMOUNT OF REINFORCEMENT.—A diagram (not shown here) gives values of vertical shearing stress developed with the several percentages of reinforcement used. These beams were all of 6 ft. span and 1:2:4 concrete and were tested at about 60 days' age and all failed by diagonal tension. It is evident that the shearing stress developed in these tests is greater for beams with the larger reinforcement. It is possible that this change is due to the greater deformation (or greater curvature in the elastic curve) of the beams having light reinforcement. Possibly the fact that at the same load tension cracks will be present in the concrete, at points nearer the supports in the beam with the lighter reinforcement on account of the higher tensile stresses developed in the reinforcing steel, has a bearing upon the difference in web resistance. That the bond stresses developed are not the occasion of the variation may be judged from the fact that the beams reinforced with deformed bars carried no higher loads than those with plain round rods.

EFFECT OF RATIO OF LENGTH OF SPAN TO DEPTH OF BEAM.—From curves of a limited number of beams, it seems that web resistance decreases with the increase of this ratio.

Beams with Reinforcing Bars Bent Up.

These consisted of (a) bars bent up to a point 2½ ins. below the top of the beam at the end; (b) bars bent up to 5 ins. below the top; (c) bars bent up to 2½ ins. below the top and with washers attached to the end of the bars; (d) bars bent up to 5 ins. below the top and with nuts and washers attached; and (e) part of the bars bent and part straight.

PHENOMENA OF TESTS.—In the beams without nuts and washers as soon as the concrete at the bottom was sufficiently stretched, a vertical tension crack formed at some point between the beam support and the bend of the bar, extending from the bottom of the beam to the level of the reinforcing bars. After the formation of this vertical crack, the tension in this part of the beam is taken mainly by the reinforcing bar; and as its depth below the top of the beam (and therefore the moment arm of the resisting forces) is considerably less than in beams having the bars horizontal throughout, the tensile stress developed in the bar at this section is greater than in beams having the reinforcement horizontal throughout. The vertical shearing unit-stress actually developed is also greater than in beams having the bars horizontal, and the resulting diagonal tensile stress is therefore greater. As the tensile stress in the steel at this section is greater than when the bars are horizontal, the amount of bond brought into action toward the end of the bar must be greatly increased. There is evidently, then a greater chance for slip of bar in such beams than in beams where straight reinforcement is used. The formation of the vertical cracks gives a good starting point for diagonal tension cracks, and the uneven distribution of stresses in the concrete due to this crack makes diagonal tension failures occur at a lower load than would otherwise be the case. Generally, in these tests, in the beams which did not fail by tension in the steel, the failure came through diagonal tension. The inclined crack which opened up along the line of the bent-up bars, as the concrete below gradually split off, may be said to be the occasion of final failure, though the failure was essentially by diagonal tension. Whether slip occurred after this crack extended along the bars nearly to their ends is a matter of some interest.

It seems to make little or no difference in results, either as to the load carried or as to the manner of failure, whether the bars were bent up to a point close to the top of the beam or to a point 5 ins. below the top.

WEB RESISTANCE WITH ANCHORED BARS.—Although designed for failure by diagonal tension in the concrete, all of these beams failed by tension in the steel, with different phenomena than those observed in the straight rod beams. In the anchored beams it seems that considerable arch action must have developed. The report says:

It seems evident from these tests that anchorage of bars at the ends, in beams with bars bent up, if securely arranged, may be advantageous in increasing web resistance. It is true, also, that this form of construction is an insurance against failure at low loads through defective concrete or insufficient bond.

WEB RESISTANCE WITH PART OF BARS BENT UP.—With part of the bars bent up and part left straight higher resistance to diagonal tension is developed than in beams with all bars horizontal or beams with all bars bent up. It is evident also that to secure best results in providing against diagonal tension stresses, the diagonal bars should be well distributed through the part of the beam where high web resistance is needed. This may be accomplished, when there are several bars, by bending the bars in two or more lines parallel to each other, as is common practice with the ordinary reinforcement. It may be expected, then,

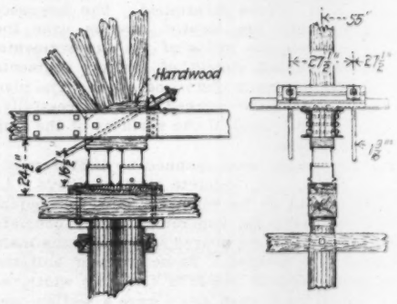


Fig. 10. Sand Boxes and Anchor Ties of Centering Under Haunches of Arch.

that good results may be obtained by bending up part of the bars if proper care is taken to get a good distribution of the diagonals.

Beams with Vertical Stirrups.

On account of certain limitations in the experiments the results of the tests on stirruped beams are not as satisfactory as on the others. The report includes a number of "tentative" deductions from the tests, which are hardly more than ideas suggested by the results and are not given out as conclusive. One thing seems certain from the tests, however, and that is that vertical stirrups do not take much stress until after the formation of diagonal cracks. There is very little elongation in the stirrups until the first diagonal crack forms, so that up to that point the concrete takes practically all the diagonal tension. The report further states that "a feature of the tests of beams with stirrups is slow failure."

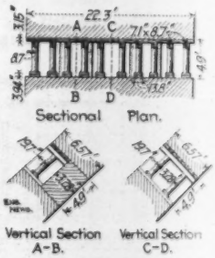


Fig. 11. Timber and Concrete Strutting Between Sections of Arch Ring.

General Comments on Web Resistance.

The bulletin concludes with the following comments:

Failures by diagonal tension in beams without web reinforcement are especially objectionable, since, as in the case of tension tests of concrete, the failure may occur without warning. Besides, although the effect of repeating the application of the load after a diagonal crack has formed has not been established, final failure undoubtedly will occur after many applications at a load much lower than that which would cause failure on first application.

In beams without web reinforcement, web resistance depends upon the quality and strength of the concrete. Cement makes a simple and effective strengthening agent. The effect of quality and strength of concrete is very marked. Even where web reinforcement is used, quality of concrete is an important element.

The stiffer the beam the larger the vertical shearing stress which may be developed. Short, deep beams give higher results than long, slender ones, and beams with a high percentage of reinforcement than beams with a small amount of metal. This difference may be due to the relation of diagonal tension to shearing stress, to the difference in opportunity for formation of vertical tension cracks, or to such a cause as a difference in amount of distortion of section.

There is a considerable increase of web strength at the earlier ages, but not much additional web strength may be counted on under laboratory conditions after 60 days. Care should be exercised that ample time is given for beams to acquire sufficient web strength before loads are applied.

The loads carried by beams with all bars bent up or inclined in the outer thirds of their length did not differ much from those with the bars all straight, but the failure is slower and warning is given. The formation of a vertical crack and the splitting of the concrete along the inclined part of the bar are characteristic of the failures.

Beams with inclined bars firmly anchored at their ends gave high web resistance and showed indications of arch action. This form of construction seems to give insurance against failure at low loads through defective concrete or insufficient bond.

The arrangement of bending up part of the bars and leaving part straight developed a good web strength and secured slow failures. This method will be particularly satisfactory when the number of bars is large enough to permit the spacing of the inclined bars at frequent intervals through the part of the beam where high web resistance is needed. A proper distribution of the diagonals is important.

Beams provided with U-shaped stirrups which passed under straight reinforcing bars generally gave high web resistance, and slow failures were characteristic of the tests. The importance of quality of concrete is also apparent in these tests. Adequate bond resistance is essential. The amount of web resistance which may be developed even with carefully arranged stirrups is limited, the limit depending upon the quality of the concrete.

Stirrups do not come into action, at least not to any great extent, until a diagonal crack has formed. After such a crack has formed, the stirrups will take stress from the beginning on a second application of the load.

The tests and calculations go to show that under the maximum loads applied to the beams the stirrups are not stressed to an amount necessary to take the entire vertical shear. The use of a fractional part of the total vertical sheer like two-thirds for application in the formulas seems to be warranted.

Considerable variation in results in beams of the same make-up was found. This is to be expected in web resistance. An even greater variation is probable under conditions of practice.

Low working stresses in web resistance are to be commended and ample provision for web strength should be made.

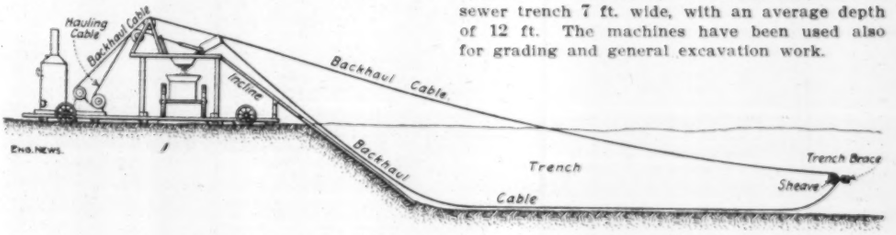
A Scraper-Excavator for Trench Work.

The use of power-operated scrapers or scraper-buckets in the excavation of trenches for sewer and other work is one of the latest applications of the scraper-bucket type of excavator, the use of which for ordinary excavation has been dealt with in our issues of Oct. 29, 1908, and March 21, 1907.

With the system described below, the trenching is done in lengths of about 75 ft. to 100 ft. At the forward end of the length is stationed a portable tipple or dumping frame, the platform of which is at such a height above the street as to allow wagons to be driven under it. One end of the tipple carries an adjustable incline extending down the head of the trench. The other end has an A-frame with two cable sheaves. In front of the tipple is a double-drum hoisting engine. The bucket has a pivoted bail. It is 3 ft. wide, of about 25 cu. ft. capacity, and weighs 400 lbs.

A ¾-in. hauling cable is attached to the bail of the scraper bucket, and is led over a sheave on the A-frame to one of the drums of the engine. The second drum carries a ½-in. backhaul cable which is led over the upper sheave on the A-frame and back to the rear end of the section being excavated; there it passes through a sheave or snatchblock hitched to a cross brace at about mid-height of the trench and returns to the back end of the bucket, to which its end is attached. This cable is used to pull the empty scraper back into position for a fresh cut. This is done without interference with the trench bracing, the cable being led over or under the cross braces as occasion may require. The general arrangement of the plant is shown in the accompanying cut.

When the bucket is at the back end of the section and ready to start, a signal is given from the trench to a man on the tipple platform, who signals the engineman. As the bucket is started by the hauling cable, two men hold its nose or cutting edge to the ground to ensure its making a cut and taking a proper load. When full, the weight is at the back of the bucket. The bucket is hauled along the bottom of the trench and up the incline to the tipple, where it strikes a trip block and is tilted up (as the hauling continues) so as to dump its contents through a chute into a car or wagon standing beneath.



SCRAPER-BUCKET EXCAVATOR FOR TRENCH EXCAVATION.
(The Heffron Trenching Co., Cincinnati, O., Makers.)

Where the ground is hard, a plow is used; this is attached to the same cables and takes the place of the bucket. The plow cuts about 18 ins. deep. It is of special form, with no handles, as the handles of an ordinary plow would be liable to catch in the bracing when the plow is being hauled back ready for a new cut. Its weight is from 400 to 700 lbs., according to size.

The force required consists of the following: 1 engineman, 1 fireman or boy, 2 men in the trench, 1 man on the tipple to give signals and supervise the loading of the wagons. With this force the machine has plowed and excavated 130 cu. yds. in a 10-hour day. If sheeting or bracing is required, there may be from 2 to 4 men in the trench to trim the sides and set up the braces, which must be placed, of course, so as not to foul the cable. It is stated that the coal consumption will be about 1,000 lbs. per 10-hour day for a 16-HP. double-cylinder double-drum engine. The tipple and incline are built upon a frame which carries the engine also; so that it is a complete and self-contained structure which can be hauled forward as the work progresses (75 to 100 ft. at a time), and hauled from place to place as required. It is said that it can be moved 100 ft. in about 20 to 30 mins. by a team of horses. When the machine is at work, the wheels are blocked and the bed is supported on blocking, as shown.

This scraper-excavator can be used for trenches under railways or street railway tracks, without interfering with the operation of cars. At Wabash Ave. and 85th St., Chicago (near the Wabash Ry. shops), the machine was used for 250 ft. of trench for a 48-in. brick sewer, passing under a number of tracks. The material was loaded into dump cars and deposited in the swampy ground of the neighborhood. The material may be used directly for backfilling or may be hauled to any dumping place. A narrow gage track may be laid through the tipple and along one side of the trench to the point of backfilling. The empty car then crosses over and returns along the other side of the trench to the tipple.

The machines have been used on sewer and street contracts in Cincinnati, Chicago, Philadelphia and Havana (Cuba). The greatest length excavated on any one contract was 7,333 ft.; the width of cut is 3 ft. The greatest depth of cut was 40 ft., although work can be done to a greater depth if required. The material excavated has included clay, gravel, sand and soapstone. One of these machines was used last year by John Funke & Co., contractors, of Cincinnati, in the excavation of trenches 22 ft. wide and 9 ft. deep at the new Woodward High School. This was in good firm ground, which required no bracing. About 100 cu. yds. in 10 hours were excavated and loaded into 2-yd. wagons. Another machine was used by John B. Washburn, contractor, of Cincinnati, for a sewer trench 7 ft. wide, with an average depth of 12 ft. The machines have been used also for grading and general excavation work.

The machine is patented, and the tipples, scrapers and plows are manufactured by the Heffron Trenching Co., 810 Neave Building, Cincinnati, Ohio.

A SOLAR TRANSIT of very compact form has recently been put on the market by Keuffel & Esser Co., of New York. The distinguishing feature of the instrument is that the horizontal axis of the solar telescope is coincident with the horizontal axis of the main telescope, although each telescope may be rotated in altitude independent of the other. This is done by a sleeve upon the main axis, to which sleeve is attached a rigid latitude arc frame holding the solar telescope. Thus the clumsy superposed solar telescope of the ordinary instrument is avoided, there is no need for a counterweight and the two glasses are placed in the proper relation one to the other. Other improvements are a knurled sleeve on the outer end of the solar telescope by means of which it may be easily revolved to the proper hour angle, a striding bubble fitting either tube, a 360° vertical circle and a large angle declination arc.

ELECTRIC SMELTING OF IRON ORE.—The Electric Iron Co., of Trollhättan, Sweden, has recently been organized in Stockholm for electric smelting of iron ore for producing pig-iron on a commercial scale. The new plant is to be erected at Trollhättan, where the Government owns a large hydro-electric power station, from which electric energy is sold at cheap rates to surrounding cities and industrial consumers. The falls yield about 75,000 HP., but will, in the future after regulation of Lake Venern, give 150,000 HP. Electric power will be bought from the Government at the rate of $7.46 per HP. year for the first 10 years and at $10 per HP. year for the following 10 years. A preliminary contract for renting up to 10,000 HP. has been drawn up.

The first installation is to consist of three ore-reduction furnaces of 2,500 HP. each. Of these, one furnace is to be in reserve. The yearly production is calculated at 15,000 metric tons of pig iron, or 7,500 tons for each furnace. The pig iron produced is intended to be used for foundry purposes only and to contain 0.4 to 1.0% of phosphorus. Phosphorus-carrying ore from the Grängesberg mining district will be used. For the reduction of the ore, German coke from the Westphalia district will be used, costing at Trollhättan $5.60, which is considerably cheaper than the Swedish charcoal ordinarily employed in Swedish blast furnaces. The pig iron is calculated to be produced at $13.65 per ton.

The cost of the new plant is estimated as follows:

Three smelting furnaces	$40,000
Ladles, ladle-cars and various appliances	4,000
Crushing plant (35,000 tons of ore and 7,000 tons of coke annually)	2,400
Transformer and motors for crushing plant, for transportation, lighting, etc.	1,600
Conveying machinery for conveying between harbor and crushing plant and to top of furnace	4,000
Machinery for conveying pig iron and slag, and tracking	3,200
Buildings for furnaces and coke storage	16,000
Building for crushers	1,100
Excavation, grading, fencing and harbor work	4,000
Office and laboratory	5,500
Superintendence and incidentals	9,100
Royalty	6,700
Total	$97,600

—Mr. H. Hullegård, Busby, Sweden, in "Electrochemical and Metallurgical Industry" issue of July, 1909.

The Government Dam Across the Rock River at Sterling, Ill.

By FRED W. HONENS,* M. Am. Soc. C. E.

The dam across the Rock River, between Sterling and Rock Falls, Ill., was built by the federal government to supply water for the Illinois & Mississippi Canal. Incidentally, the Sterling Hydraulic Co. was given certain privileges for development of water power in lieu of damages claimed to its water power at a dam ¾-mile below the site of the government dam.

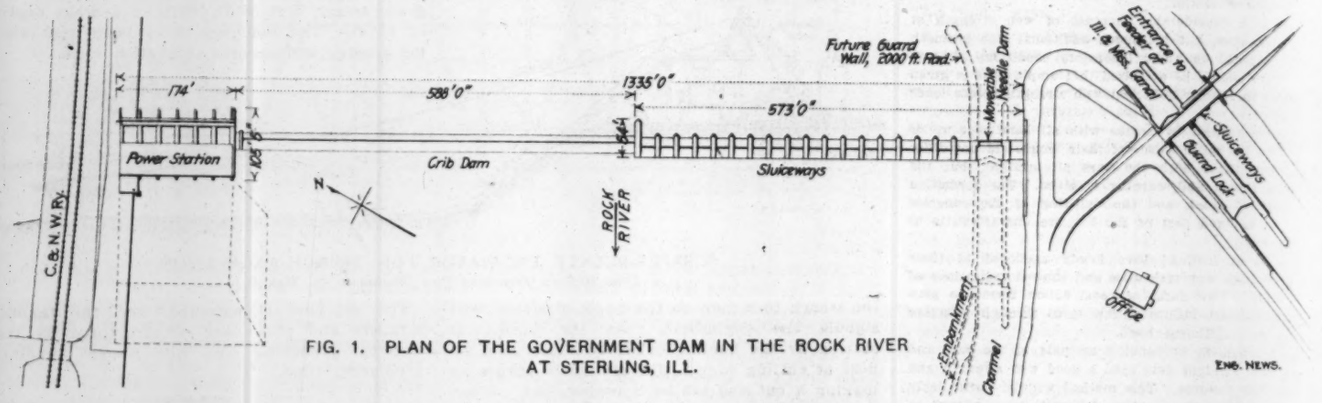


FIG. 1. PLAN OF THE GOVERNMENT DAM IN THE ROCK RIVER AT STERLING, ILL.

The feeder of the canal leaves the Rock River a short distance above the south end of the dam, and follows a course almost due south for 29.3 miles, where it makes a junction with the main line in the 28th mile. There is a fall of 1 ft. in the bottom grade from the headworks to the junction, and provision has been made for a water slope of 2.3 ft. There is but one lock, a guard lock at the Rock River. The main line of the canal crosses the divide between the Illinois and Mississippi rivers. It ascends 196 ft. from the Illinois River by means of 21 locks in a distance of about 18 miles, and descends 93 ft. to the Mississippi River by means of 11 locks in about 46 miles. The summit level is 11 miles long, making the total length of the main line 75 miles. However, the last 13 miles of the western section may be considered a separate canal, which does not draw its water supply from the pool above the Sterling dam. There would, therefore, be a total of 91.3 miles of canal (with 30 locks and nine aqueducts) obtaining water from the Rock River at Sterling.

The normal depth of the canal is 7 ft.; width at bottom, 52 ft.; width at water surface, 80 ft. The sides have slopes of 1 on 2. It was estimated that for seepage, evaporation, lockages, waste, etc., in the canal, from 180 to 300 cu. ft. of water per sec. would be required.

The Rock River has its source in the eastern part of Wisconsin, below Lake Winnebago and Green Bay. It has tributary to it a large number of lakes, the largest being Lake Koshkonong, with an area of 23 sq. miles; this is really an expansion of the river. The river enters the Mississippi three miles below Rock Island, after traversing a southeasterly course of about 286 miles. The total drainage area is approximately 11,000 sq. miles, of which 8,900 sq. miles are above the Sterling dam. The greatest width of the drainage area is about 65 miles, and the length of the river above the Sterling dam is about 218 miles. The Rock River valley consists principally of rolling prairie land, rich and well cultivated, with moderate slopes.

The annual rainfall for 23 years from 1885 to 1907 (Wisconsin Survey Bulletin No. 20) varied from 20.6 ins. to 36.4 ins., with a mean of 30.8 ins. The total fall of the river is about 340 ft., or an average fall of about 1.2 ft. per mile. The steepest slope is between the mouths of the Catfish and Pecatonica rivers, which is 1.9 ft. per mile. The average slope from Oregon to Sterling is 1.3 ft. per mile, while at the rapids at Sterling the fall between the government dam and the dam of the Sterling Hydraulic Co. is about 10 ft.

The maximum discharge of the river at Sterling is about 40,000 sec.-ft. The average discharge computed from 18 observations made in September and October, 1904, was 3,890 sec.-ft., the lowest being 1,860 sec.-ft. and the highest 5,442 sec.-ft. During a period of about two years the discharge at Milan, Ill., near the mouth of Rock River, was not less than 1,000 sec.-ft. more than three times, and then for very short periods. The river at Sterling is not subject to sudden rises of any magnitude. It does not carry any great amount of drift, though it occasionally has a heavy run of ice. During the winter of 1906 a gorge was formed about 25 miles below Sterling, which filled the river with ice to a point an equal distance above the city, causing the highest water ever known in the vicinity. At the dam site the water stood slightly above El. 210 (Hennepin datum).*

The dam is located at the head of the rapids, where the river is a little more than ¼-mile wide. The banks are about 25 ft. high, and are of limestone, overlaid with clay. The river bottom is of solid limestone, practically level, and there is about 2 ft. of water at low stages.

The crest of the dam of the Sterling Hydraulic Co. is at El. 199.3, and the normal pool level above the government dam is 208.3. Above the site of the dam there are wide areas of bottom land, which have been overflowed. All lands below the contour of El. 211 were described, and overflow damages amounting to $79,483 were paid for 1,436 acres of land. It was necessary for the Chicago & Northwestern Ry. to raise about a mile of its track east of Sterling, for which it was paid $24,300. The basin or reservoir formed by the dam extends about eight miles up-stream. It is about a mile wide at its widest place, and at El. 208.3 (the normal pool level) its area is about 97,000,000 sq. ft.

The decree of the U. S. District Court awarding the flowage damages was based on an exhibit stating that the dam should have in it 168 lin. ft. of sluiceways and 1,040 lin. ft. of movable dam, with sills 4 ft. below the normal level of the pool. A number of plans were proposed for this dam, among others a plan for a movable dam of the overhead-bridge type. Fig. 1 is an outline sketch of the dam as finally constructed. It has a total length of 1,335 ft. and is divided into three parts: (1) the crib dam, 588 ft.; (2) the sluiceways at the south end, occupying 573 ft.; (3) the power station at the north end, 174 ft.

Sluiceways.

At the south end of the dam there are 19 sluiceways 21 ft. wide, closed with cylindrical steel gates; and one sluiceway 35 ft. wide, closed with a needle dam. The latter opening, with its masonry, is in reality the upper end of a lock authorized by Congress, for which the appropriation for construction has not yet been made.

MASONRY.—The foundation for the masonry is a soft limestone, the surface of which lies between Els. 197 and 198. The coping is at El. 214. There are 17 intermediate piers, which are 34 ft. long, 6 ft. wide, and about 17 ft. high. Each contains approximately 121 cu. yds. of concrete. The up-stream end is pointed to form a cutwater. Recesses were made in the concrete at the down-stream ends of the piers to receive the ends of the horizontal trussed beams which form the hinged supports of the sluice gates. Each pier is reinforced with four old 30-lb. steel rails set vertically, extending from the foundation to within 6 ins. of the top, and placed at the corners of the two recesses of each pier. Two rails 30 ft. long were placed

FIG. 2. THE GOVERNMENT DAM IN THE ROCK RIVER AT STERLING, ILL.

(The overflow portion is a rock-filled crib dam, ending at a power-house on the opposite shore. The remainder of the dam consists of a series of vertically revolving gates in sluiceways. The wooden bridge at the right spans a 35-ft. opening for a future lock.)

*Junior U. S. Engineer, U. S. Engineer Office, Sterling, Ill. (Resident Engineer in charge of the construction of the dam.)

*Hennepin datum is 428.075 ft. above mean sea level, and all elevations mentioned in this article refer to it.

horizontally about 2 ft. below the top of the masonry. Recesses were also made at the up-stream ends of the piers, in which 15-in. I-beams can be set to form the upper support of a needle dam to close the openings in case of accident to the gates.

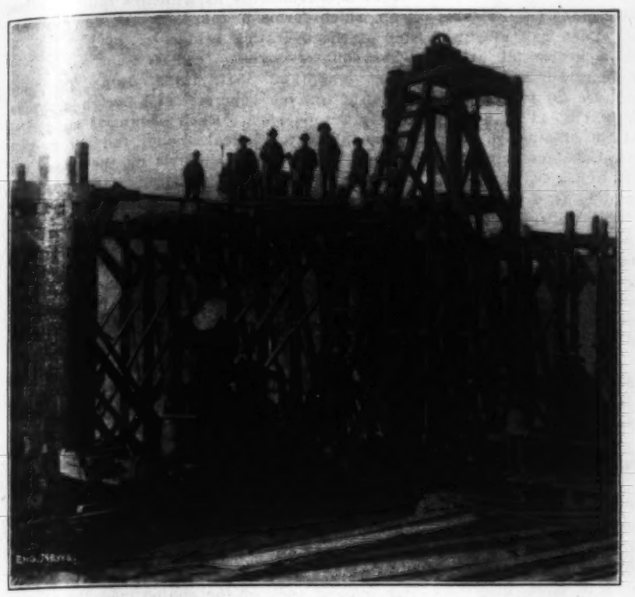


FIG. 3. TRAVELING ELEVATOR FOR DEPOSITING CONCRETE IN THE FORMS FOR THE PIERS OF THE SLUICEWAY SECTION OF THE STERLING DAM.

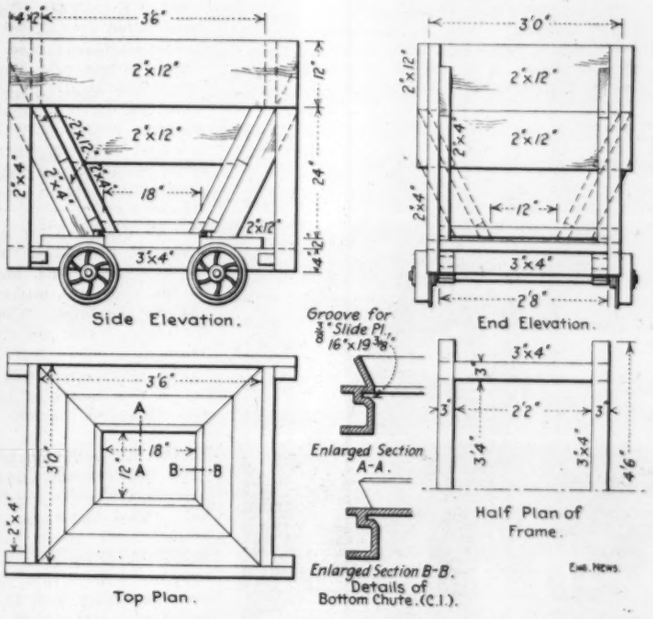


FIG. 4. CAR FOR HANDLING CONCRETE AT THE STERLING DAM.

The outside or river pier (between the crib dam and sluiceways) is 54 ft. long, 8 ft. wide, and about 17 ft. high; it contains 263 cu. yds. of concrete. The abutment is 31 ft. long and 3 ft. 6 ins. wide at the coping, with a total length of 77 ft., including steps and retaining wall. It is built against the solid rock of the south bank and contains 174 cu. yds. of concrete. The lock (not yet built) is to be 35 ft. wide, 170 ft. between hollow quoins, and about 225 ft. long. The top of the lower miter sill is to be at El. 193. The upper end has been constructed. The breast wall is 13 ft. wide, and serves for the foundation of the needle dam which at present closes this opening.

FIG. 5. ARRANGEMENT FOR HANDLING CONCRETE CARS.

(The track at the left comes from the mixing plant; the loaded car (A) is run upon a turn-table (B), and diverted to the lateral track (D) leading to the pier under construction. The empty car (C) has been transferred to a stub track to clear the loaded car.)

The sluice gates (when closed) rest on oak sills between the piers, supported on low concrete foundations 13 ft. wide. A trench was excavated in the rock, from 2 ft. to 4 ft. deep, and a long sill constructed in sections, extending entirely across the space occupied by the south sluiceways. The piers were constructed upon this. The oak sills, 12 ins. and 10 ins. high (for the sluice gates and the needle dam respectively) are anchored to the concrete by six 1½-in. anchor bolts, 6 ft. long, extending into the solid rock.

Fig. 2 shows the completed work of the sluiceways and the crib dam. The wooden bridge at the right spans the 35-ft. opening for the lock. At the far end of the dam may be seen the concrete foundations for the power-house.

CONCRETE CONSTRUCTION.—All of the construction work was performed by hired labor. The work on the cofferdam was started July 21, 1906, and the last of it was removed about the middle of December, 1906.

A box cofferdam was constructed, allowing the river bottom to be laid bare. It enclosed a space extending 600 ft. into the river, about 100 ft. wide at the outer end and 250 ft. wide along the river bank. The width between sheeting was 6 ft. and the height about the same. It was filled with a natural mixture of gravel, sand and clay taken from the spoil banks of the canal. The filling was loaded into wagons through a trap by slip scrapers, and hauled to the cofferdam, where it was unloaded by hand with shovels. The water was about hub deep while the cofferdam was being built. Quarry refuse was cast against the inside. The cofferdam was quickly built and proved to be remarkably tight.

Natural gravel and screened pebbles from the prism of the canal were used in the concrete. The gravel consisted of about 50% clean, sharp and fairly coarse sand and 50% pebbles. The Portland cement used in the construction of the 3,600 cu. yds. of masonry in the south sluiceways amounted to 4,010 bbls. of Atlas and Marquette cement, or an average of 1.14 bbls. of cement per cu. yd. The cement was received at the railway siding about a mile away, hauled to the dam site over a narrow-gage railway (built for the construction of the canal), and stored in sheds. A cement house was built over the cement track, about 50 ft. from the mixer, the track extending to the platform of the mixer. Ordinarily a flat car filled with about 200 sacks of cement was kept at the mixer platform. In case of rain and at night, the car was pushed into the cement house, where several hundred sacks of cement were usually kept as a reserve.

MIXING AND HOISTING PLANTS.—About 65% of the concrete was mixed with a Smith mixer mounted on a truck with engine and vertical boiler. The remaining part was mixed by hand. The mixer was elevated on a crib about 2½ ft. high, so that the concrete could be dumped directly into a car. The materials were dumped into the mixer through an extension chute from a bottom-dump car on a track overhead. Directly over this track and a short distance back from the mixer, were the cement chute and a pair of hoppers for the materials (one for gravel and the other for pebbles) each having a capacity of about 7 cu. yds. The bottoms of the hoppers were high enough to allow the material car to pass under them to be charged, and their tops were low enough to allow the materials to be dumped into them from 3-yd. side dump cars.

It was thought desirable to have a concrete elevator that could be moved intact from pier to pier. This elevator (Fig. 3) was constructed of 6 × 8-in. timbers and securely bolted to the frame of an old pile-driver, taking the place of the leads, which were removed. Timbers were laid on the river bottom and maple rollers used for moving ahead. After each move, the elevator and frame were firmly blocked. The elevator was operated by the pile-driver engine, which also furnished the power for moving ahead. About two hours were consumed in making the change from one pier to the next.

Bottom dump cars (Fig. 4) having a capacity of about 20 cu. ft. were used in carrying the concrete from the mixer to the forms. A track for the concrete cars was laid from the mixer to the site of the outer pier. This track was parallel to and about 20 or 25 ft. above the up-stream ends of the masonry.

A short spur track was laid at right angles to this track, leading to the elevator. The concrete cars were transferred from the mixer track to the elevator track by means of a small turntable placed at the intersection. A short stub track was laid in the angle between these two tracks; on this the empty car was placed, to pass the car of concrete. A short turnout was built close to the mixer, so that three concrete cars could be used at one time.

Fig. 5 shows these tracks, with the mixing plant in the background. A loaded concrete car

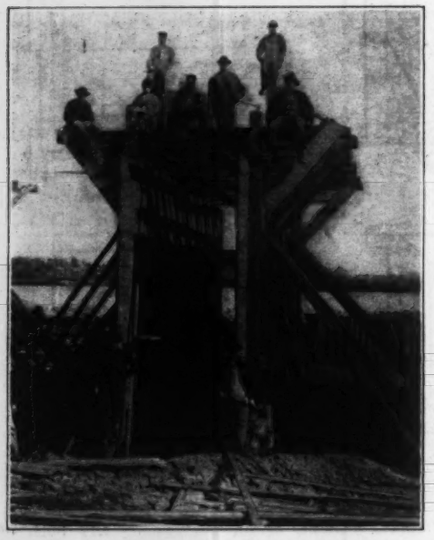


Fig. 6. One of the Forms for the Sluiceway Piers.

(A) is on the track from the mixer, ready to be pushed on to the turntable (B); an empty car (C) is on the short passing track, and a third car is at the mixer. Track (D) leads to the elevator. The concrete consisted of 1 part cement, 4 parts gravel, and 4 parts pebbles. For the forms, 6 × 8-in. posts, 2 × 12-in. lagging, and ⅝-in. tie rods were used. The posts were tied together at the top with 6 × 8-in. timbers, to which the track for concrete cars was fastened. Fig. 6 shows the forms.

Owing to a scarcity of laborers, the rock excavation was not completed so that concrete work could be started until Sept. 14, 1906. It became evident that strenuous efforts would have to be made if the concrete work was to be completed during the season of 1906, which the possibility of spring floods and ice made almost imperative. Accordingly, the conditions were declared to constitute an emergency, and the work was carried on for 10 hours per day; the wages were increased from $1.75 to $2 for an eight-hour day, making the wages $2.50 for ten hours for unskilled labor.

A total of 3,600 cu. yds. of concrete was mixed and deposited, 2,351 cu. yds. being machine mixed and 1,249 cu. yds. hand mixed. The hand mixing crew (consisting of an overseer with 19 laborers and 4 teams) mixed and deposited about 35 cu. yds of concrete in 8 hours. The mixing plant required an overseer, 2 enginemen, 1 fireman, 1 team and 28 laborers. Each of the intermediate piers contains 121 cu. yds. of concrete and it required from 12 to 14 hours to fill a form with concrete, including the time required to move and get ready for depositing at the next form.

NEEDLE DAM.—The needle dam closing the lock opening is of the Poiree type. It has three steel trestles 9 ft. apart, as shown in Fig. 7. Each revolves about a horizontal axis at the base, and the trestles lower behind an oak sill when the sluiceway is open. The trestles are built of 4-in. channels; they are 10 ft. high, 6 ft. 8 ins. wide at the base, and weigh 700 lbs. each. When in use, they are held in a vertical position by pine planks 3 × 12 ins. pinned to the top. These serve also for a foot bridge. The needles are white pine timbers 6 × 8 ins., 12 ft. long; they are supported at the top by a 6-in. I-beam carried on brackets at the top of the trestles. The outside end of the I-beam rests against an oak timber anchored in a recess in the masonry. At the bottom the needles rest against the oak sill.

SLUICE GATES.—The sluice gates (Fig. 8) are constructed entirely of steel. Each has a cylindrical segmental face with a horizontal axis; and is hinged to a trussed beam supported between the piers. The gates are 20 ft. 11 ins. wide, and have a circular height of 11 ft. 6 ins. The tops are at El. 209, and the sills at El. 199. A gate consists of six double A-frames or radial arms sheathed at the outer ends with ⅜-in. steel plates bent to a radius of 17 ft. 6 ins. The frames have a triangular form, with the hinge at the apex. They are connected by gusset plates at the hinge, two cross braces of angles at one-third points, and by two circular angles at the ends, the latter forming the attachment for the sheathing. The gate is braced laterally by angles which are riveted to the arms of the frames.

The sheathing which forms the face is made up of five sheets of steel which are spliced at the centers of the four inside frames. The pitch of the rivets is 2½ ins. Each sheet is reinforced and stiffened by angles riveted horizontally between the ends of the arms of the A-frames, the lower one forming the joint with the sill. Two loops are riveted to the sheathing about 2 ft. above the bottom, by which the operating chains are attached to the gate with clevises. There is a clearance of ½-in. between the sheathing and the masonry. To prevent leakage at this place, a strip of 4-ply rubber packing 6 ins. wide is bolted to the edge of the sheathing and lapped back on to the masonry (Fig. 9). Provision is also made for placing rubber packing on the bottom of the gate, though all the gates have not yet been so equipped.

Each trussed beam is 23 ft. 9 ins. long, and is built of two 10-in. channels having a cover plate ⅜ × 16 ins. on the up-stream side and batten plates on the reverse side. It is trussed in a horizontal plane, as shown in Fig. 9. The beams rest in recesses so that a plate can be slipped into them over the beam to take the upward thrust of the gate. The beam is also anchored to the masonry by means of a steel yoke around each end, which is connected by a hold-back strap to a 2¼-in. anchor pin set 2 ft. in the masonry. The strap is 8 ft. long and has a turnbuckle in the middle, the latter being used during construction only. This detail is shown in Fig. 9.

The total weight of one sluice gate, not including the counterweight towers and chains, is 21,535 lbs., divided as follows: sheathing, with angle ribs and gusset plates, 6,707 lbs.; trussed beam complete with rod and pins, 3,006 lbs.; 6 A-frames and ties, 11,400 lbs.; 2 cast-iron thimbles and chains, 187 lbs.; 2 yokes and hold-back straps, 235 lbs.

COUNTERWEIGHTS AND TOWERS.—Part of the dead load of the gate is counterbalanced by concrete counterweights hanging in steel towers on the masonry (Fig. 10). The towers are 16 ft. high, 5 ft. 4 ins. long, 4 ft. 6 ins. wide, and all except the two on the abutments carry two counterweights. They are built up of angles. The posts are anchored through shoes to the masonry and at the top are connected by 8-in. channels which carry the sheave beam. This beam consists of a pair of 8-in. channels placed back to back, between which are four cast-iron drum sheaves for the counterweight chains. The towers are connected by a lattice railing 18 ins. deep which forms a guard for the down-stream side of the operating bridge.

The counterweights are 2 ft. 6 ins. wide, 4 ft. 4 ins. long, and 3 ft. 6 ins. deep. They are made of gravel concrete and weigh approximately 2 tons each. Each weight is suspended by means of a vertical anchor rod through its center. The rod has a clevis on the upper end and a nut and 6-in. cast-iron washer on the lower end. Over the washer, short pieces of rails were placed lengthwise to reinforce the concrete. Each counterweight is attached to the gate by means of a ⅝-in. dredge chain, which is carried over a pair of sheaves at the top of the tower and is bolted to the outside frame of the gate near the sheathing. Vertical guides of white pine, 4 × 6 ins., are bolted to the towers, and the corners of the counterweights are recessed to fit them, as shown.

HOISTING CARRIAGES.—The gates are operated by means of a hoisting carriage traveling on a bridge across the up-stream ends of the piers. This bridge is made of three lines of 10-in. I-beams, covered with a 3-in. pine deck. The two operating chains of the gate pass through cast-iron thimbles which rest upon steel plates bolted to the planks. To hold the gate open at any elevation, a dog is slipped between the links of each of the chains over the thimble and the load is thus transferred from the hoisting carriage to the bridge. The carriage (Fig. 11) has two drums, operated by gearing by means of a large hand wheel. The carriage was designed by Mr. Chr. Holth, M. E., but was subsequently slightly modified.

MANUFACTURE AND ERECTION.—The sluice gates were manufactured by the Russel Wheel & Foundry Co., of Detroit, Mich., at a price of 4.2 cts. per lb. The 28 counterweight towers were built by the American Bridge Co., of New York, at a cost of $1,476. The prices were f. o. b. cars at Rock Falls, Ill. Two operating carriages were built by the Chicago Bridge & Iron Co. at $351 each. Drawings of the gates and towers were furnished to the contractors, from which they prepared the detailed shop drawings. The work in both contracts was done under practically the same specifications, from which the following extract is taken:

> All structural steel shall be made by the open-hearth process and shall be of the grade known as medium steel, and all rivets shall be of rivet steel. Both shall conform in all respects to the Manufacturers' Standard Specifications (Carnegie's Pocket Companion, edition of 1903), and must not contain over 0.08% of phosphorus.

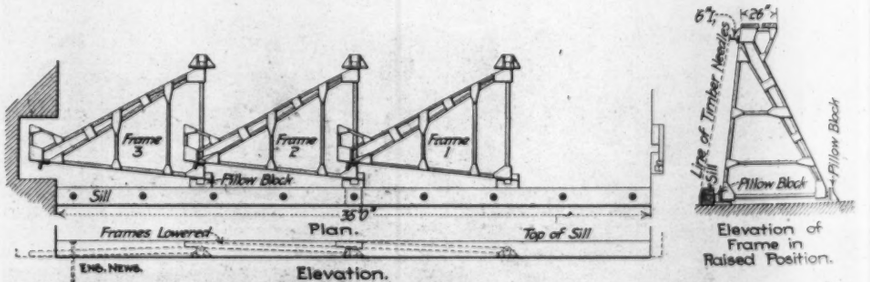


FIG. 7. NEEDLE DAM OF THE POIREE TYPE FOR CLOSING THE 35-FT. OPENING FOR THE FUTURE LOCK.

The sluice gates were erected by hired labor by the United States during the season of 1907. The specifications required that each gate be assembled in the shop and its parts marked. The trussed beams and A-frames were manufactured and shipped complete; the sheathing, ribs and gussets were shipped in three parts, and the diagonal rods separately. The materials were received at the railway siding on the canal right-of-way, transferred to narrow gage flat cars and hauled to the dam site. The parts of the gates were hauled to the place of erection

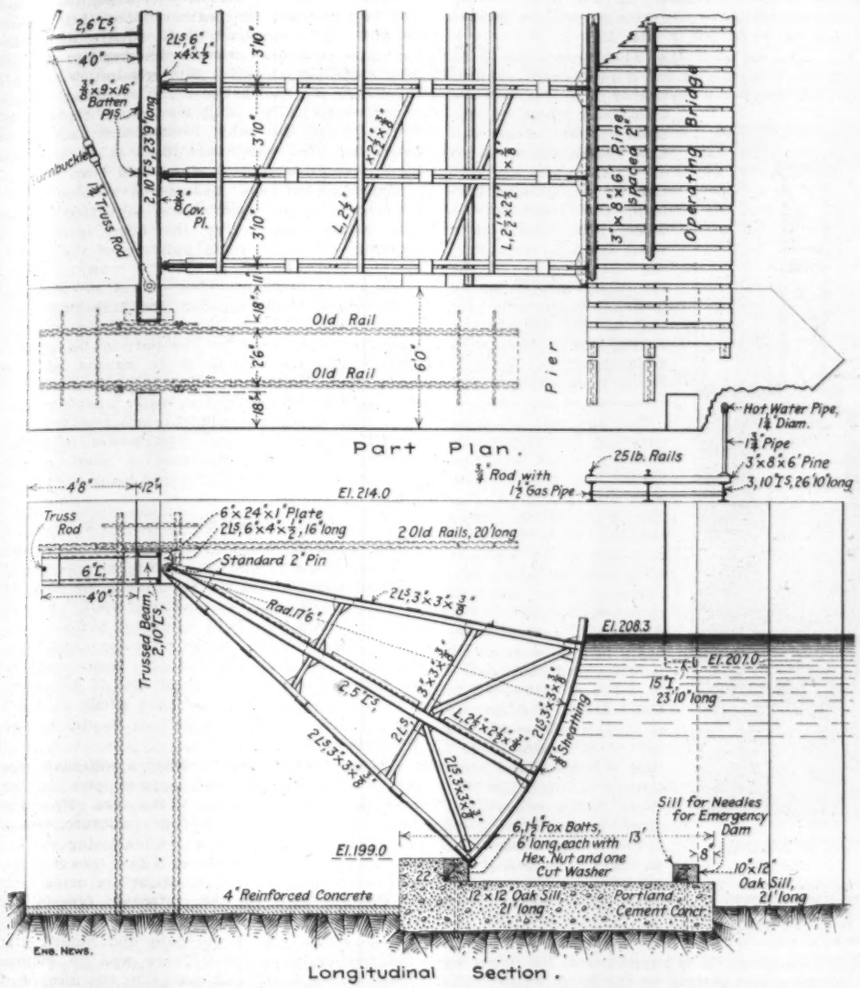


FIG. 8. REVOLVING SEGMENTAL SLUICE-GATES FOR THE STERLING DAM.

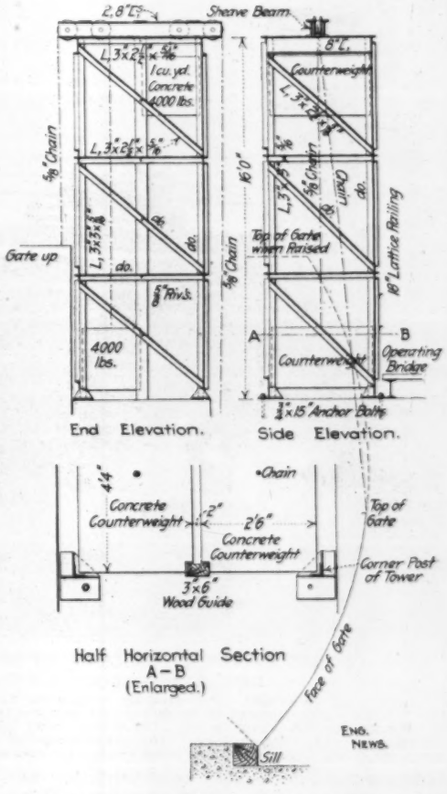


Fig. 10. Towers and Counterweights for the Sluice-Gates.

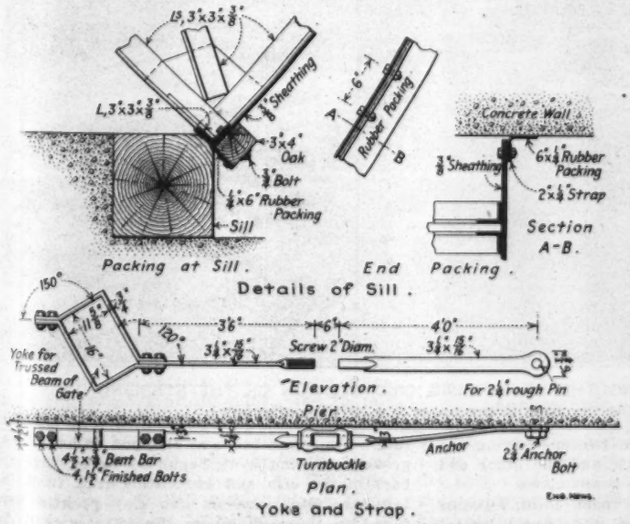


FIG. 9. DETAILS OF SLUICE-GATES.

by wagon over a temporary bridge across the lower end of the masonry, and lowered into position by means of a 10-ton crab mounted on a stiff-leg derrick. The derrick was moved forward on 6 × 8-in. timbers which spanned the sluiceway and rested on the piers. The trussed beam was first dropped into place, and from it and the operating bridge an erecting platform was suspended. The 19 sluice gates at the south side of the river were erected while the water in the river was flowing through the sluiceways. Fig. 11 shows one of the gates partly raised by the operating carriage, and shows also the counterweight and towers.

Crib Dam.

The fixed portion of the dam (Figs. 12 and 13) is a rock-filled crib 588 ft. long, 24 ft. wide, about 9 ft. at the crest. It is provided with flashboards for raising the water to normal pool level. The crib is built with pine timbers 6 × 8 ins., laid flat and pinned together with drift bolts ¾ × 16 ins. There are four rows of longitudinal timbers 8 ft. apart, the individual timbers being 16 ft. long and arranged so that the alternate rows break joints in the succeeding panels. A tier of cross timbers is placed every 8 ft.; these, with the longitudinal tiers, divide the crib into three rows of pockets, 8 ft. square. These pockets are filled with rock excavated from the tail race of the power plant (Fig. 13). Double-lap pine sheeting is spiked to the face of the dam, against which the refuse from the quarry is placed for backing. This filling extends to the top of the sheeting and to a distance of about 20 ft. up-stream.

The deck of the dam is divided by a 14-in. step into two parts, one-third being up-stream and two-thirds down-stream, with the crest at El. 206. The apron has a downward slope of 4 ft. 3 ins. in 16 ft., and is covered with 3-in. oak spiked to white pine purlins, 8 × 8 ins. and 6 × 12 ins. The purlins are fitted into notches cut in the cross timbers and are fastened to them by ¾-in. drift bolts. The up-stream third of the dam has a downward slope of 2 ft. in 8 ft. from the crest to the face. It has a deck of 3 × 12-in. pine covered with ¼-in. steel plates. The plates are 8 ft. square and have four rows of 11/16-in. holes through which they are spiked to the purlins.

FLASHBOARDS.—Flashboards are placed on the dam when necessary to raise the water to normal grade. Along the crest at intervals of 4 ft., notches 1 in. wide and 3 ins. deep are cut in the steel plates. A pair of 2¾-in. angles is riveted to the bottom of the plates, with the backs 1 in. apart and the ends protruding 1 in. beyond the plates. Through the ends of the angles a ¾-in. bolt is placed and a bar of Norway iron ¾ × 1½ ins. stands between the bolt and the back of the notch in the steel plate. The bottom of the bar passes through a small casting, lag-bolted to the side of the upper purlin, and rests on top of the apron. The bar is bent so that the portion above the crest is vertical, and 2-in. planks are fastened with U-bolts. The bars are so designed that if the pool level rises more than 1 ft. above normal, the bars will bend, throwing the flashboards down.

FISHWAY.—A fishway is provided at the north end of the crib dam, between the masonry of the power plant and a small concrete wall or pier parallel to it. It passes below a cross-wall between the two. It is 9 ft. wide and has a slope of 1 in 5. It is built on a timber crib similar in construction to the lower part of the crib dam. The water is admitted through an opening in the cross-wall and traverses a zigzag path of about 150 ft. to the point of discharge.

Power Plant.

The power plant is located at the north end of the dam, within the corporate limits of the city of Sterling. The U. S. government has constructed the controlling works, thus retaining absolute control of the river. The substructure,

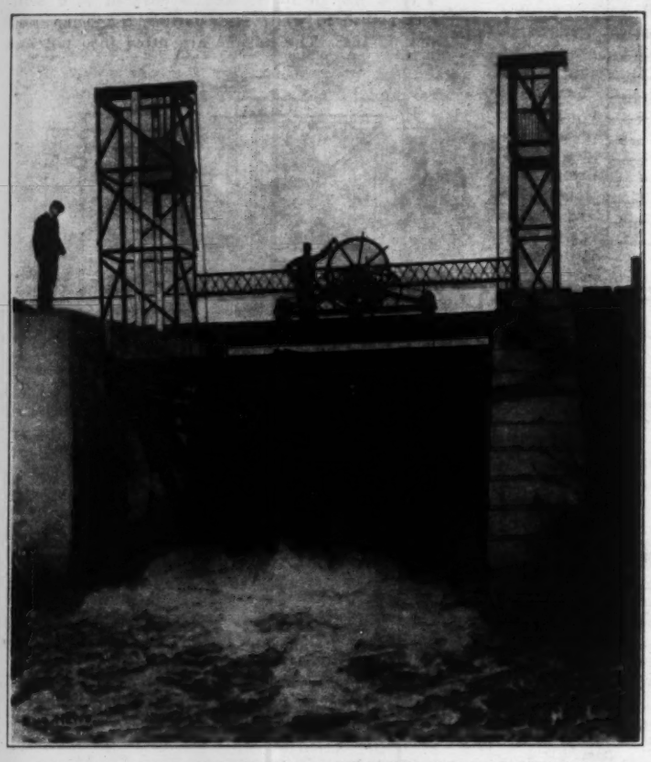


FIG. 11. ONE OF THE 25 SLUICE-GATES OF THE STERLING DAM (RAISED ABOUT 4 FT.)

(On the service bridge is the operating carriage for handling the gates. The two hoisting chains attached to the face of the gate are led to drums operated by gearing by the large hand wheel. The towers carry the gate counterweight; the one on the right has only one counterweight as it is on the abutment; the other is on a pier and has counterweights for two gates.)

tail race, etc., have been constructed by the Sterling Hydraulic Co., and the building will be erected and the equipment installed by the company during the present year.

CONTROLLING WORKS.—The controlling works consist of six cylindrical sluice gates with counterweights and masonry, similar to those at the south end of the dam and previously described. The gates and sills were placed 4 ins. lower than those at the south end of the dam. Instead of cutwaters at the up-stream ends of the piers, inclined reinforced concrete beams (Fig. 14) were constructed for the supports of the drift racks. The concrete beams are inclined at an angle of 45° with the face of the piers, into which they are anchored by reinforcing bars, the lower ends being trenched into the rock. The beam is 2 ft. wide and 3 ft. deep, and is reinforced with 15 plain rods ¾-in. diameter.

The drift racks are carried on 10-in. I-beams supported on the concrete beams, the two lower I-beams being also supported by a small concrete pedestal half way between the two concrete beams. The lower ends of the drift racks rest on a concrete foundation or sill. A small bridge for handling drift is carried on the tops of the concrete beams. The inclination of the rack tends to force the drift to the top and facilitates its removal. The inclined rack has a greater area than a vertical rack, and therefore would not be so quickly obstructed. There is an area of about 70 sq. ft. under the concrete beam, which allows the water to be equalized back of the rack and makes it practically impossible for the entire hydrostatic load to be brought upon a rack even if it were entirely covered with drift.

POWER STATION.—The masonry of the power station abuts on and is bonded to the masonry of the government controlling work. The sluiceways terminate in the wheel rooms, in each of which two turbine wheels are located in tandem, as shown in Fig. 15.

The side walls of the wheel room are 2 ft. thick, 16 ft. high, and are of reinforced concrete. The reinforcement consists of ¾-in. plain round bars, laid about 4 ins. from the face of the wall and spaced 6 ins. c. to c. These walls are carried on foundations that form the sides of the wheel pits; these latter walls are 3 ft. wide, flaring out to 4 ft. at the top in the last 30 ins. to form the supports for the floors. Reinforcing stirrups or U-bars were embedded in the concrete 3 ins. from the top and crosswise of the wall.

The end wall is composed of two reinforced-concrete beams extending across the wheel room, with an opening (A, Fig. 15) 3 ft. 6 ins. deep between them. This is to be used for spillway in case of an emergency. Ordinarily it will be closed with wooden sluice gates (B). The lower beam is 3 ft. wide and 9 ft. deep, and has two 20-in. I-beams embedded at the bottom. The corners of the wheel room are cut off at angles of 45°, thus enlarging and reinforcing the junction between the sides and lower beam, ¾-in. plain square rods being bent so as to reinforce and bind the two together. The upper beam is 2 ft. wide, 5 ft. deep and carries the west wall of the building. It is supported at its center by a concrete post resting on the beam below. The walls of the wheel pit extend 4 ft. beyond the building line and contain recesses for use in building cofferdams for making repairs. The opening between these walls is divided into three parts by two vertical 12-in. I-beams having one end cemented into the rock and the other end anchored into the concrete beam above.

For a floor in the wheel room, 18-in. I-beams were laid on the foundation walls and 6 ins. of concrete reinforced with No. 10 expanded [illegible] was laid between the beams and on their [illegible] flanges. Two openings 10 ft. square were [illegible] for the wheels, each wheel frame resting on [illegible] 8-in. cast-iron columns. The generators are located over the wall between the second and [illegible] wheel rooms. This wall was made double the thickness of the other walls, and that [illegible] above El. 208.5 was made 13 ft. 4 ins. wide to give mass for absorbing shock and vibration.

Reinforced-concrete beams have been constructed over the wheel rooms, supported on the side walls; these carry the floor, machine [illegible] building, etc. The main building of the power station is to be 50 × 165 ft., constructed of brick. It is to be provided with a 10-ton [illegible] crane on a track running the full length of the building. The building is to be heated by steam, a boiler room for the purpose being provided. The installation is to consist of two units, each having a 750-KW. generator, exciter, and six 66-in. vertical water wheels geared to a line shaft extending practically the full length of the building. The power is to be transmitted to the factories in Sterling and Rock Falls, the extreme distance being about two miles.

Construction.

The work of constructing the crib dam, and controlling works and excavating for the power station, was carried on simultaneously and by hired labor, during the season of 1907. A temporary bridge was built over the south sluiceways, being carried on the piers for about two-thirds of the distance and the balance of the way on trestles at the lower end of the piers. The latter third was built on a grade of about 6%, landing at the river bottom shortly beyond the outside pier.

At the close of work in 1906, a cofferdam was left which enclosed the outside pier of the masonry at the south end of the dam. From the two outside corners of this enclosure, wings were built to the north shore, enclosing the entire space occupied by the crib dam, power plant, tail race, etc., an area of about six acres. All of the materials for the cofferdam (gravel, cement, lumber and other supplies) were received at the south end of the dam and hauled over the temporary bridge. There was no storage space at the north end except in the unwatered river bed.

The water was drained to a sump where two 6-in. centrifugal pumps were installed, only one being used except immediately after a heavy rain. The river bed was stripped of loose rock, gravel, etc., and work begun by laying the timbers in the crib and excavating rock from the tail race, etc. One or two clay pockets were found in the rock where the cribs were to be

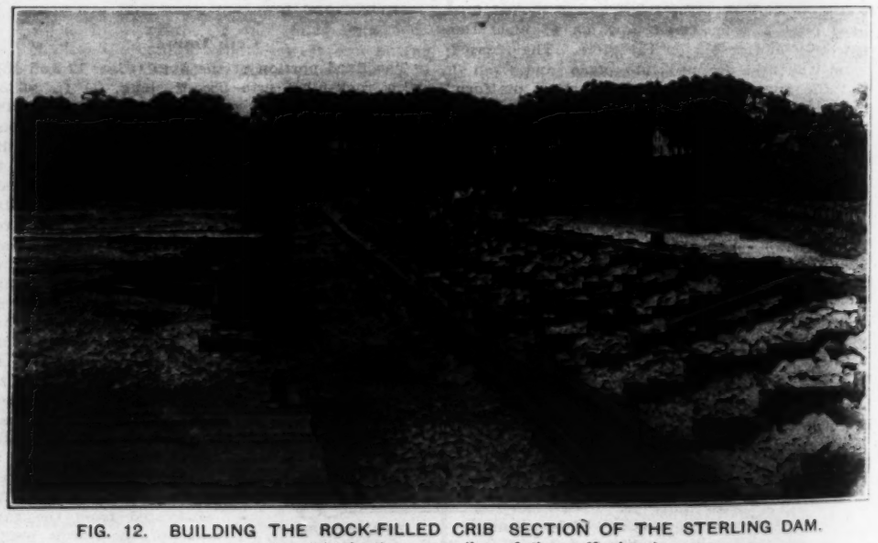
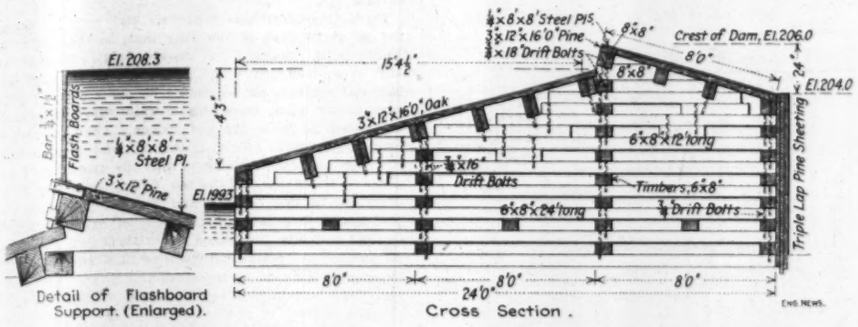


FIG. 12. BUILDING THE ROCK-FILLED CRIB SECTION OF THE STERLING DAM.
(At the right is the upper line of the cofferdam.)

built. These places were excavated and filled with crib work. As fast as the crib was built it was filled with the best of the rock from the excavation at the power station, the waste being placed in front of the crib. The average depth of the rock excavation at the site of the power station was between 11 and 12 ft., and for the tail race it varied from 12 ft. to about 3 ft. as it receded from the power station.

The concrete was similar to that used at the south end of the dam, excepting that crushed rock was used instead of pebbles. It was mixed in the same Smith mixer but charged by wheelbarrows. The concrete was also hauled to the forms in wheelbarrows, a steam hoist being used for elevating the barrows on the government work, and an incline for the other work. The concrete in the power station was deposited during November and December, in freezing weather, the minimum temperature being zero, and the average about 20° F. The water used in the concrete was heated almost to the boiling point and live steam was turned into the mixer while mixing. The concrete was made medium wet. As soon as a form was filled and floated, side boards were put on and a canvas cover fastened over the boards. Live steam was then turned into this space from one end of the section.

The last concrete deposited during the season was that for the floors of the wheel rooms. After the concrete had been deposited, covers of old canvas were laid over the floor beams and placed on frames in front of the opening from the wheel pit. The space was then heated with an ordinary coal stove. This concrete was as good in quality as any deposited.



Detail of Flashboard Support. (Enlarged).

Cross Section.

FIG. 13. SECTION OF CRIB DAM, WITH DETAIL OF FLASHBOARDS AND SUPPORTS.

Operation.

Under normal conditions the flashboards will be in place on the dam and the pool level maintained at El. 208.3 by means of the sluice gates at the south end of the dam. By operating the gates in time, it is possible to maintain the desired level without a fluctuation of more than 0.2 or 0.3 ft. One man can readily operate a gate and there is always a man on duty (day and night); other men are available by telephone call.

A test was made with two men alternately, operating the hoisting carriage, to determine the time required to operate a gate. To disconnect the chains of one gate, move the carriage ahead to a second gate, and connect the chains ready to hoist required 2 mins. The men raised the gates the first 5 ft. in 5 mins. and continuing raised the bottom of the gate to El. 208 (the height necessary to clear the ice) in 8 mins. more, making a total of 15 mins. required to raise the gate 9 ft. It would be necessary to have four men for each hoist if it were desired to open the gates at this rate. There being two hoisting carriages at the south end of the dam, it would be possible to raise the 19 sluice gates 5 ft. in a total of 1 hr. 10 mins., and to full height in 2 hrs. 30 mins. All of the gates could be closed in one hour.

It was estimated that, with the water below the dam at El. 206 and above at El. 208.3 (the sill being at grade El. 199) each sluiceway would discharge 1,288 sec.-ft. of water and the 19 sluiceways 24,670 sec.-ft. The back water will very seldom be as high as El. 206. Except at times of extreme high water the river can be entirely controlled with the south gates.

However, before the run of ice and the spring floods occur, the flashboards would be removed and the water forced to flow over the crib dam by closing the necessary gates. Before placing or removing the flashboards, the pool level is drawn down by means of the sluice gates so that not more than 10 or 12 ins. of water is running over the dam. The flashboards are then placed or removed by men wearing rubber boots, walking on the dam. The bars are first dropped into place and a plank floated to position, lifted on edge and pushed into place, where it is held by the pressure of the water. The lower course of boards would be placed entirely across the dam before starting the second course.

In connection with the investigation of the river bottom just below the crib dam, the writer had the lower boards of the flashboards placed across the dam, about 80 ft. of the boards being in place at one time. Four extra bars were used and a plank would be taken off at one end and carried to the other end and set up. It required one man a little over four hours to carry the first course of boards entirely across the river (about 575 ft.). About 10 ins. of water was running over the crest at the time and the boards were not fastened to the bars.

In case a flood should occur while the flashboards were in place, the flood being of such magnitude that it could not be discharged through the sluice gates, the water would rise about a foot above the normal level and then the bars would bend under the increased head, thus removing the flashboards without other damage than the loss of the planks.

During the winter months, the ponds above and below the dam freeze over and a wedge-shaped piece of ice is formed on the up-stream face of the sheathing of each gate, effectually sealing the gate shut. A heating plant has been installed for thawing the ice around the gates. This plant consists of a 15-HP. boiler, a 900-gal. steel heating tank and a Knowles tank pump. The plant is housed at the south end of the dam, and a distributing pipe extends the full length of the sluiceways. The latter is carried on gas pipe standards and also serves as a railing for the operating bridge (Fig. 10). It is provided with expansion joints and cut-off valves, and has a tee over each sluiceway for connecting a steam hose.

The water is heated in the tank with steam from the boiler to about 200° F. From the tank it is pumped on to the back of the gate, the heat thus absorbed melting the ice on the reverse side of the plate. To loosen the ice around the hoisting chains and at the angle between the sides of the gate and the masonry, live steam is turned into the pipe line and applied directly to the ice through the steam hose, a piece of ¾-in. pipe 6 ft. long being used for a nozzle. The ice is then broken up with a spud and allowed to escape by raising the gate. In the latter part of January, 1909, it was found necessary to raise the gates. The ice was about 6 ins. thick and during the day the temperature was as high as 60° F. An overseer with five men thawed out and operated 18 gates in 10 working hours.

The plans for the dam were approved by the War Department on July 17, 1906, the first work of construction was begun on July 21, 1906, and the government portion of the work was completed so that water was turned into the canal for the formal opening on Oct. 24, 1907. No work was performed between the middle of December, 1906, and the middle of June, 1907, the actual time of construction being about 10 months.

The total cost of that part of the dam constructed by the government, including engineering but not including office costs or flowage rights, was approximately $92,000. The dam and power plant were designed by Mr. L. L. Wheeler, M. Am. Soc. C. E., assisted by the writer. Major C. S. Riché, U. S. A., is the Engineer Officer in charge of the government work. Mr. Wheeler is the U. S. Assistant Engineer, and is also consulting engineer for the Sterling Hydraulic Co. The writer was Resident Engineer in immediate charge of the construction work. Thanks are due to Messrs. L. L. Wheeler, A. O. Rowse, and the Russel Wheel & Foundry Co. for assistance rendered in connection with this paper.

FIG. 14. INCLINED BEAMS OF REINFORCED CONCRETE TO SUPPORT THE DRIFT RACKS ACROSS THE SLUICEWAYS OF THE POWER-HOUSE OF THE STERLING DAM.

Preliminary Chemical Treatment as an Aid to Slow Sand Filtration; Indianapolis Water Co.*

By H. E. JORDAN.†

The Indianapolis water-supply, which is furnished by the Indianapolis Water Co., consisted, until 1904, of well water. The amount obtainable from this source was becoming insufficient for the needs of the city, and, accordingly, in 1902, the first construction work on the present slow-sand filtration plant was begun.

The supply for the filters is taken from White River or Fall Creek, the latter being used as a duplicate source only. Both these streams rise within the State of Indiana; the former has a drainage area of 1,520 sq. mi. and the latter of 500. Each flows through on area which may be characterized as glacial drift. White River, for a portion of its course, flows through limestone outcroppings and is about doubled in size at low-water flow on account of the infiltration of spring-water from this stratum. The mean low-water flow available in both these streams is approximately 150,000,000 gals.

The original installation at the filter plant consisted of three open beds, each 1.6 acres in area, and two clear-water basins of a total capacity of 5,000,000 gals., together with various administration buildings and regulating houses.

The water from White River, before reaching the plant, flows through the company's canal, which is seven miles long, with an average width of 50 ft. It was expected to obtain a certain amount of sedimentation during the flow from the head of the canal to the filter plant, but the development of a water-power pumping station below the filter plant made the flow too rapid for this purpose.

There was some question as to the need of covering the beds, and as to the best size of the individual units. The operation during the first winter developed the fact that, during the months of January and February, the operation would be considerably hampered if the filters were not roofed; also, on account of ease in handling, smaller units were preferable. So, in 1905-06, the original plant was modified to its present condition, now consisting of six covered filters, each .776-acre in area. [See Eng. News, April 26, 1906, for description of reinforced-concrete roof of filters.—Ed.]

The condition of the raw water as to the amount of suspended matter at certain seasons of the year was the reason for experimental work, done during the year 1906-07. It will be remembered that the classic investigations of Piefke in Berlin, and Fuller at Lawrence, Mass., in 1894, were with waters of high bacterial pollution, but carrying a relatively insignificant amount of suspended matter.

It was realized that there would be developed certain problems not touched in their investigations regarding slow sand filter operation, on account of the fact that White River, during spring freshets, carries as much as 1,500 parts per million of suspended matter. The rivers of Indiana represent very clearly the middle class of raw waters in this country. White River contains, during approximately two-thirds of the year, a relatively small amount of suspended matter, and is filtered with ease by slow-sand filters; during the remainder of the year it carries rapidly fluctuating amounts of clay and silt, which renders its purification a problem of quite different nature.

The removal of bacterial life, as developed in the earlier researches, was the principal problem of the operators of a slow sand plant. These waters, however, containing variable amounts of inorganic suspended matter, present, as the chief problem, the removal of that turbidity, and, when that is effected, the other result has been attained. The operation of English filters with a raw water of this type has disclosed the fact that the deposition of silt in the sand layer not only decreases the production per run, but, decreasing the bacterial efficiency, makes the higher numbers of bacteria in the effluent—consequent upon flood seasons—more extreme. Not only are the unfavorable conditions effective at the particular time of the flood or freshet, but the amount produced in successive runs steadily diminishes, and, apparently, on account of the covering over of the bacterial coating with silt particles, the organic purifying power of the sand layer becomes less.

Just what amount of suspended matter may be handled by means of sand filters has been the subject of considerable question. The observations at Indianapolis are to the effect that a turbidity higher than 15 to 20 parts per million will cause a compacting of the sand layer and carriage of silt into the effluent. Filters can handle, for a day or so, turbidities of 1[illegible] but such conditions cause rapid increase in loss of h[illegible] necessitate hurried cleanings and disarrange the g[illegible] schedule of operation, often resulting in insuffici[illegible] amounts of filtered water for distribution.

During the past three years there ha[illegible]een an average of 82 days per year when the turbid[illegible] of White River water exceeded 40 parts per million[illegible] his representing the amount as now understood th[illegible] will not produce a settled water of optimum quali[illegible] for slow sand filtration. During the remainder of t[illegible] year, on the other hand, the raw water, after settli[illegible] may be filtered at rates from six to seven and one-[illegible] million gallons per acre with the production of a [illegible]isfactory effluent.

There is another aspect of this high turbi[illegible] during the 80 or 90 days of the year that, to those of us in Indianapolis, appears to render single filtration of any type inefficient. A water of uniform and low bacterial content, not exceeding 50 per c. c. [illegible]ny many days in the year, represents a water-supply of a character such as to be above suspicion. The experience of every water-works official is that at some time the effluent from his plant is going to bear the unmistakable evidence of fluctuations in the raw water. Data from plants operating in this country and Europe, both slow sand and mechanical, show that periods of extreme pollution or high turbidity, or sudden fluctuations from one degree of quality to another, produce, with a single filtration system, an effluent of depreciated quality. The "peak," as it may be called, in the raw water, either germ or inorganic, results in a finished water of less satisfactory character. It is true that by reducing rates of filtration these difficulties may be obviated, but a filtration plant consisting of such an excess area of filters, of any sort, as to enable reduced rates to remove this difficulty would be an extravagance.

It was with these ideas in mind that the Indianapolis Water Co. sought to so modify its original filter installation that there might be, for this short period of the year, some added detail of the plant not representing a great increase in fixed charge, that would aid in the solution of these difficulties. The problem that has been met at the local plant is also one of moment in the Poughkeepsie, Albany, New York, Philadelphia, Washington and Pittsburg purification problems, and, in certain reverse conditions, in the operation of the Harrisburg mechanical filters.

The treatment of waters of this character has been the subject of several investigations in years past. Fuller, in 1898, at Cincinnati, devoted considerable study to the operation of a slow sand filter, preceded by a coagulation and sedimentation of the raw water. The operation at this place was not successful, due, as is recognized at present, to the insufficient sedimentation following the application of the chemical. The report of Colonel Miller regarding experimental filtration operations at Washington, D. C., in 1900, was to the effect that either mechanical filters or modified slow sand filters should be installed at that place. The investigations of Hardy and Longley since that time, in the operation of

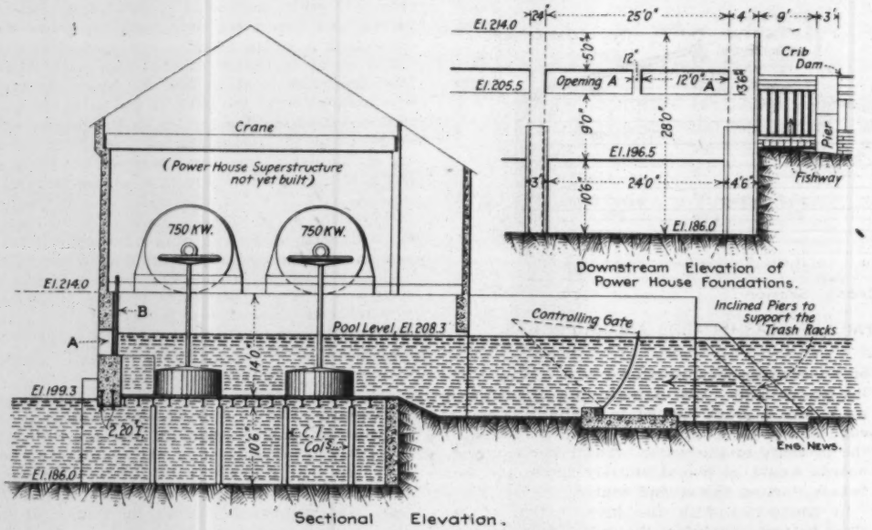


FIG. 15. SECTIONAL ELEVATION OF THE POWER-HOUSE AT THE STERLING DAM.

FIG. 1. FIRST FLOOR OF CHEMICAL HOUSE, INDIANAPOLIS WATER CO., SHOWING FEED HOPPER ABOVE AND EJECTOR BELOW USED IN FILLING SOLUTION TANKS WITH IRON.

*Slightly condensed from a paper read before the Chicago Section of the American Chemical Society, May 21, 1909.

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the slow sand filtration plant installed in that city, have led to the conclusion that a coagulation plant should be constructed so that the over-load might be removed from the filters. In the operation of the Philadelphia filtration plants, various methods of pre-treatment have been tried. Plain sedimentation, followed by rapid sponge filtration, has been used at the Roxborough and Belmont plants. The Torresdale sand filters are preceded by rapid sand filtration. The operation of the Pittsburg filtration plant has been attended with the same problems and there are, at present, being conducted a series of experiments for the purpose of ascertaining the amount of pre-treatment necessary to render the influent water to the filters of satisfactory quality. Goetze, in 1903, presented to the American Society of Civil Engineers the results of the operation of the filtration plant at Bremen, Germany, where a double filtration was resorted to and the effluent of a primary filter, when not satisfactory, was passed through a secondary filter. This treatment, although successful in producing a final effluent of satisfactory and uniform quality, was open to the criticism that it did not obviate the difficulties in the operation of the primary units, since it was not possible to prevent the deposition of silt within the sand layer. Later, the process of treatment with sulphate of alumina was adopted, as indicated in Dr. Goetze's paper before the International Congress of Hygiene in September, 1907.

FIG. 2. PORTION OF SETTLING BASIN OF INDIANAPOLIS WATER CO., SHOWING BAFFLE WALL, PRESSURE WASH-WATER MAIN AND SLUDGE OR SEDIMENT GUTTER.

Probably the first installation of a modified slow sand filter in this country was at Ferncliff-on-the-Hudson, on the private estate of the Astor family. This plant, designed by George W. Fuller, is so arranged that at times of high turbidity in the raw water, it may be treated with alum and passed through a settling basin so as to give to the filters an influent water containing a relatively small amount of suspended matter and bacterial life. In 1908, at Poughkeepsie, N. Y., the settling basin was provided with a series of baffles, and, during certain seasons of the year, the water is treated with alum.

The modification of the Indianapolis plant, so far as pre-treatment was concerned, was taken up definitely in the spring of 1907. The author, during that year, investigated the operation and construction of filtration systems at Lawrence, Mass.; New Haven, Conn.; Little Falls and Hackensack, N. J.; Philadelphia and Pittsburg, Pa.; Washington, D. C.; Columbus, Cincinnati and Lorain, Ohio. Plain sedimentation, rapid sand or sponge pre-filtration were not considered acceptable on account of high fixed charges, and uncontrollable fluctuations in their effluent. Double filtration would have entailed a permanent investment of too great an amount. It was finally decided that a settling basin of moderate size, preceded by coagulation when needed, would solve the problem.

A settling basin, fourteen acres in area, was constructed and, during the winter of 1907-08, at the times of extreme turbidity, sulphate of alumina was applied at a temporary coagulation plant installed in the laboratory building. The operation of this was successful enough to indicate the wisdom of a permanent installation. Accordingly, designs were completed for a chemical house and permanent improvements in the settling basin. These improvements were completed by Nov. 1, 1908, and the operation has been carried on according to the new scheme during the past winter. This consists in the passage of the water from the canal to the laboratory or administration building, where, if necessary, the coagulant is applied to the water. From here it flows to the settling basin, and, after passing through this, on to the filter beds.

The chemical, or head house, is a three-story brick-veneered reinforced-concrete structure. The lower, or basement floor is partly used for extra storage of coagulant. At one end of this are placed the outlets from the slacker tanks and saturators, so arranged that the sludge drawn from either may be collected in a sump, and removed from this in barrows or washed through a sewer into Fall Creek below the plant. The ground floor of the building is used for ordinary storage of coagulant. On this floor is also placed the ejector, which is used for lifting the sulphate of iron into the tanks. The method of preparation of the iron solution at the Indianapolis plant is quite different from that at any other place. The quantity of iron required for a tank-full of solution, usually 1,500 lbs., is taken to the second floor of the building and is placed in a hopper, which extends down through the floor to a point within 6 ft. of the lower floor. Leading from the bottom of this is a 3-in. pipe, controlled by a valve, which ends directly over a small ejector (Fig. 1). When it is desired to fill one of the solution tanks, the valve in the bottom of the hopper is opened and the iron flows down through the pipe and falls directly over the stream of water flowing from the nozzle. This ejector is connected to the city mains and works at a pressure varying from 50 to 60 lbs. The stream of water picks up the particles of iron, passes them through the throat tube, into the 2½-in. lead-lined pipes which lead to the various solution tanks. By this method it is possible for a 1,500-lb. charge to be lifted into the solution tanks within from eight to ten minutes, during which time it is practically dissolved. The ejector is then shut off and the chemical attendant opens a pressure line, so arranged as to deliver the water to the solution tanks, and the filling is completed. During the time that this supply of water is being passed to the tanks, the solution is kept constantly stirred by means of a small Root air-blower. This is placed on top of one of the tanks and the pipes leading from it are carried to the various solution tanks. These pipes go to the bottom of the tank and there branch out into a cross-form, with ¼-in. perforations looking downward. This process gives a thorough and inexpensive stirring of the solution in the tanks. Within twenty minutes from the time that the ejecting is begun, the tank is filled and the iron completely in solution.

During ordinary turbidities, the strength of the coagulant solution is 5%, but when unusual amounts of coagulant are being added, it is increased to 7.5%, since it is more economical to put a greater amount of the chemical in the individual tanks than to refill them so often. These solution tanks, four in number, each having a capacity of 500 cu. ft., are located upon the second or operating floor of the head house, directly over the saturator tanks. The solution is passed by gravity from them through an orifice box upon a mezzanine floor and from that through a 4-in. cast iron line to the point at which it is applied to the raw water. Upon the operating floor are placed the various valves controlling the flow of the raw water through the chemical house, the idea being to divert a certain portion of the untreated water into the house where it receives the treatment with lime. There is also on this floor the Venturi meter indicator, showing the amount of water passing to the settling basin. At the west end of this floor are placed the slacker tanks, four in number. These tanks are made of galvanized iron, 6 ft. high and 5 ft. in diameter, so situated that their tops are flush with the floor. Each slacker is provided with motor-driven stirrers, constructed on the same design as those in use at Cincinnati and Columbus. The electric power current is purchased from the Indianapolis Light & Power Co. They are at present operated in two pairs, the charge of lime being placed in one, and, after the slacking, it is allowed to flow over into the second, where the suspension becomes more uniform. It is the intention, after certain experimental work has been completed, to replace these slackers in more permanent form with two of the same size which may be used alternately, from which the milk of lime will be passed into a larger equalizer tank having a capacity five or six times as great. By this process, it will be possible for the milk of lime to be fed in an even mixture to the raw water. An alarm bell, regulated in the laboratory, gives notice to the attendant when to put in the charge of lime, 100-lb. amounts being fed at intervals varying from 10 to 90 minutes.

Both hot and hydrated lime are kept on hand. This is primarily on account of a feature of the contract which specifies that if the contractor shall fail to make delivery within a certain period after the date of an order, the company may use hydrate at the hot lime price. As a matter of results obtained, there has been noted no difference. As regards stability and convenience in handling, the hydrate is far superior. The irregular use of coagulants and the large quantities used at these periods, makes the use of the more stable hydrate preferable, but under present cost conditions, it has been found more economical to use hot lime, even though there is a certain percentage of carbonization or air slaking.

The application of chemicals, when lime and iron is being used, is somewhat different from that ordinarily followed. It appeared, from certain preliminary experimental data, and also from the general proposition of the application of lime in connection with iron, that the lime should precede the iron. Accordingly, it is applied to the raw water as it passes through the head house.

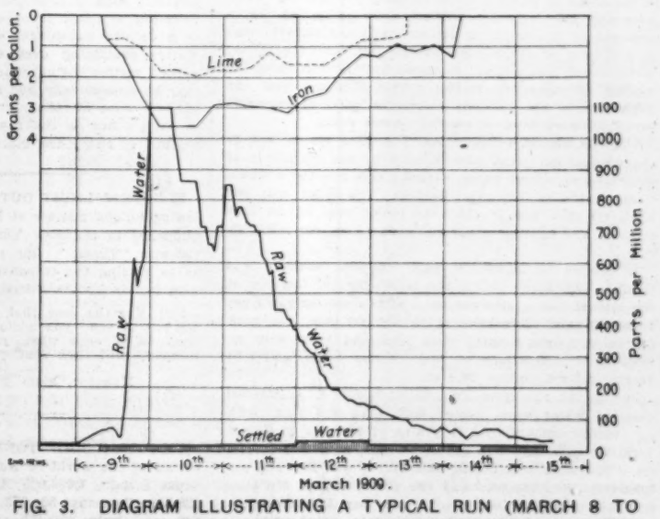

FIG. 3. DIAGRAM ILLUSTRATING A TYPICAL RUN (MARCH 8 TO 15, 1909) OF COAGULATION PLANT OF INDIANAPOLIS WATER CO.

(Showing turbidity of raw and settled water and unit quantities of chemicals used.)

The iron solution is carried through the 4-in. cast-iron pipe to a point either 400 ft. distant, or just where the raw water enters the settling basin, 1,600 ft. from the chemical house. By this means, it is possible to apply the iron either 5 or 20 minutes after the lime has been applied. This makes it possible for the dose of lime to correct the carbonic acid contained in the water before the iron enters it, and eliminates certain reverse chemical reactions, which would occur if the iron were applied first.

The conduit leading the treated water to the settling basin opens into the basin at a point 6 ft. below the water level. By this, it is possible for the coagulated water to pass into the basin without disturbance.

During preliminary runs in the winter of 1907-8, in the absence of a Venturi meter, weirs were placed at the inflow of the basin so that it might be possible to get data as to the amount of water being treated. The fall of the water over the weir into the body of water in the basin resulted in a breaking up of the coagulation, which, as has been noted at other places, did not re-form. The result was to interfere with the settling out of the suspended particles. So, when the basin was constructed in permanent form, the inflow of raw water was so arranged that this would not occur.

The settling basin is 14 acres in area, averaging 10 ft. in depth. The rated capacity of the basin is 45,000,000 gals. By means of a pretty thorough baffling system (Fig. 2) it is divided into seven compartments. The shortest distance of travel through the basin is 5,000 ft. During the preliminary operation, the baffling was much less complete, and, although the basin had the same rated capacity, it was very clearly evident that there was a much less amount of displacement. Certain observations indicated the passage of some of the raw water to the outflow points within six hours.

If there is any one thing that is essential to the operation of a coagulation system, in connection with slow sand filtration, it is that no coagulum shall pass to the sand layer. The experiments conducted at Cincinnati by Fuller in 1898, with a basin giving as high as 24 hours sedimentation, demonstrated the fact that that period was not great enough to remove the objectionable amount of coagulated material. The experience of Goetze in Bremen, and Willcombe at Ferncliff, was to the same effect. It was found that the runs of the filters, instead of being increased by the coagulation process, were, in a great number of cases, decreased by half, on account of the fact that the coagulated particles of mud passed to the sand layer and formed a mat upon the surface of the sand. These same difficulties were met in the Jerome Park experiments [New York City].

The experience at the Indianapolis plant indicates a necessary sedimentation period of not less than 48 hours. This effectually removes all but 15 to 20 parts per million of suspended matter, which amount represents a satisfactory condition for the operation of slow sand filters.

The efficiency of sedimentation, as obtained during the past fiscal year, may be summarized as follows:

During the periods of coagulation (87 days total) the raw water contained an average of 16,500 bacteria per c.c., with a maximum of 150,000, and the settled, 1,300; a reduction of 91.63%. The turbidity of the raw water averaged 110 parts per million, and the settled, 13; a removal of 89.1%. It is not so much the removal that is a matter of satisfaction as the fact that the settled water, after coagulation, averaged but thirteen parts per million of suspended matter. This indicates that the difficulties of the previous years—the peaks of excessive turbidity—have been successfully dealt with.

There is herewith illustrated (Fig. 3) a typical run of the coagulation plant as evidenced by the conditions of the raw and settled water. During this run there was a total of 183,500,000 gals. treated. The labor cost per 1,000,000 gals. was 16 cts.; the power used in the lime slackers and stirring apparatus cost 0.7-ct. per 1,000,000 gals.

A volume of 25,800,000 gals. of low turbidity was treated with alum during the latter part of the run at the rate of 1.01 grains per gal., with a cost of $1.39 per 1,000,000 gals. A volume of 157,750,000 gals., the peak of the run, was treated with lime and iron, with an average of 1.99 grains of iron, costing $1.59, and 1.14 grains of lime, costing 28.4 cts.

During the run from Feb. 15 to March 1, 253,000,000 gals. of water were treated with lime and iron, with an average amount of 1.77 grains of iron, or $1.40 per 1,000,000 gals. and 1.25 grains of lime, at a cost of 44.2 cts. The labor cost during this period was 25.5 cts. per 1,000,000 gals. treated, and the power charge for stirring and slacking use was 1.2 cts. per 1,000,000 gals. The base costs of chemical during this period of treatment were: Alum, 97.21 cts. per 100 lbs.; iron, 55.93 cts.; hot lime, 23.7 cts.; hydrated lime, 28.9 cts. These costs include the purchase payment, plus the trackage and hauling charges and labor cost in getting the chemical in place in the storage rooms.

The effect of preliminary chemical treatment upon the operation of the filters themselves is best evidenced by the comparative results of the plant during the past two years. During the year 1907-8 the runs of the filters averaged 25.6 days in length, with a production of 56,800,000 gals. per acre between cleanings, or a daily rate of 2,220,000 gals. per acre. During 1908-9, with the settling basin in operation during a greater portion of the year, the average length of run was 26.6 days, with a production of 78,300,000 gals. per acre between cleanings, a daily rate of 3,010,000 gals. per acre, or an increase in daily rate of 800,000 gals. per acre. During the latter part of 1908, and a portion of the fiscal year of 1909, there have been three runs of filters completed, in which the old sand layer has been completely washed and replaced to the full depth of the filter. The average length of runs of these beds was 53.6 days, with a production of 205,000,000 gals. per acre between cleanings, or an average daily rate per acre of 3,820,000 gals.

The filters have been operated during the past year at rates as high as 5,500,000 gals. per acre per day without lessening the efficiency in any regard. Experience indicates that this amount is not the limit of the ability of the filters to satisfactorily purify the water, but that from 6,000,000 to 7,500,000 gals. will be as effectually purified as at the lower rates. The only limitation at present upon the rate of the filters is the fact that the total amount of water used in the city is less than the capacity of the plant.

In point of bacterial efficiency, the filters, during the year of 1907-8, handled a raw water containing, on the average, 6,366 bacteria per c.c., producing a filtered water averaging 126 per c.c., or an efficiency of 98.43%. During 1908-9, the raw water contained 5,575 bacteria per c.c.; the settled water, 803, and the filtered 30, representing a total bacterial reduction of 99.47%.

It has been possible for us to observe the comparative results with the use of alum, or lime and iron. We have noted that either, with careless handling, will not do the work for which they are intended, and, on the other hand, with proper care and intelligent supervision, either will satisfactorily remove both turbidity and color.

There is no question that the lime-iron process must be accompanied by laboratory supervision if it is to be handled successfully and economically. In point of relative cost of chemical, the evidence is clearly that lime and iron is cheaper.

Regarding the cost of the entire process of modified sand filtration, there is considerable misapprehension. Instead of the process making a higher cost per million gallons, as believed by many, the reduced area of filters necessary, for a rate of 6,000,000 to 7,500,000 gals. per acre, instead of 3,000,000 gals., reduces it.

It is not possible to go into detail regarding the cost element in a paper of this length. Suffice it to say, that for a 20,000,000-gal. plant, interest charges for filters, head house, and basins need not exceed $5 per 1,000,000 gals. Operation charges, without pumping, but including coagulation, will amount to not over $5 per 1,000,000 gals.

Data regarding various single-filtration systems elsewhere indicate that this amount is not in excess of their cost, and considerably under that of many. Taking into account, further, that it is possible to produce a water of uniform quality, not running to such excessively high numbers, as is the case in many single-filtration systems, it appears to us that such method is a decided advantage, and, as a general proposition, waters containing over 40 parts per million of suspended matter during approximately a third of the year, may be economically and satisfactorily treated by means of slow sand filtration, preceded by chemical treatment at such times as the raw water contains an excessive amount of suspended matter.

ELECTRIC LIGHT OUTAGES are handled in the following unique manner at Bangkok, according to an item published in the New York "Sun" and credited to the Calcutta "Times." Our readers may take their choice as to placing the responsibility for the item, which we give for its human interest, as follows:

Sir: For the case that your electric light should fail we beg to send you enclosed a post card, which please send us at once when you find your light out. The company will then send you another post card.

Yours truly,
Manager, Siam Electricity Company, Limited.

THE WAR-SHIP TONNAGE of the seven leading navies of the world in November, 1908, was as follows: Great Britain, 1,669,005; United States, 685,426; France, 628,882; Germany, 524,573; Japan, 371,891; Russia, 240,943; and Italy, 220,458. When the vessels now being built will have been completed, the relative order only of France and United States will be changed, as the former nation will then have a tonnage of 801,188 as against 770,468 of the latter. Great Britain with a tonnage of 1,871,176 will still maintain her two-power standard, viz., a preponderance of 10% over the combined strengths of the navies of the two next strongest naval powers.

The Design of an Eight-Mile High-Head Hydraulic Conduit.

By LARS JORGENSEN,* Assoc. M. Am. [illegible] E.

CHOICE OF TYPE.—Almost all early high-head power developments made use of flume construction for carrying the water from the point of diversion to the beginning of the pressure pipe line. It was the easiest and cheapest way, and the factor of safety was of little account because it was also very low in the other branches of the system.

The main objection to a ditch running along on a steep hillside is its liability to wash out. If the ditch is lined with concrete this liability is not so great, although it exists. Across flat country, however, a ditch or canal whether lined or unlined may be regarded as a safe conduit for power developments. In place of the ditch along the steep hillside, we have the choice between tunnel, pipe line, and a combination of the two. The third represents, perhaps, the best solution of the problem.

Of these three different kinds of conduit, the tunnel is probably the safest. If it is driven through solid rock, the sides can be dressed well enough to bring the value of n down to 0.017, in which case, with a water velocity of 6 ft. per sec., it may not pay to line the sides with concrete if the only object is to bring this value down to 0.012. This depends, however, on the price of power and the cost of development. The extra cross-sectional area required with $n = 0.017$ would be about one-third more than with $n = 0.012$ for a tunnel with a carrying capacity of 300 sec.-ft. of water.

Next to the tunnel a concrete pipe line completely buried is the safest kind of conduit. If made of proper material it should last as long as the tunnel, in other words, the depreciation and maintenance cost is very small. The cost of building it would be about twice the cost of building a ditch or flume, and half the cost of building a tunnel, per lineal foot. The tunnel, however, makes short cuts and therefore may compare favorably with the concrete pipe line in cost. If depreciation and maintenance are taken into consideration, a ditch-and-flume conduit will not show up much better than the concrete pipe line in cost, and where reliability of service is essential it is not to be considered.

For economy of water, the system of tunnels and flow-pipes should be a closed one, in order to increase the average head. At light load we would have nearly the full static head, and at all loads up to the full we would have some pressure in all parts of the conduit. The flat, upper part of the pipe line should be so designed and installed as to become a gravity conduit only when carrying water sufficient to develop maximum power output at the power-house.

Besides the increase in average head, another advantage of a closed conduit lies in the fact that the wheels draw water directly from the point of diversion, and, in case the conduit is provided with a small secondary reservoir at the beginning of the pressure pipe proper, this reservoir acting as a stand-pipe, the closed conduit has no disadvantages. However, the gravity portion of the conduit should be continuous with the pressure portion, to avoid loss in head by re-acceleration of the water; the secondary reservoir, therefore, should be connected to the main conduit by a tee and a short piece of pipe. In this way the secondary reservoir will at the same time act as a differential surge pipe.†

THE ACTUAL CASE.—The consideration just stated, when applied to the actual case discussed in the following, led to the adoption of a closed conduit consisting of buried concrete flow-pipe and rock-tunnel pressure pipe, as shown in diagram by Fig. 1. The static head at the wheels is 1,104 ft.

THE FLOW-PIPE.—The gravity flow-pipe is 40,000 ft. long and has to carry a maximum flow of 200 sec.-ft. of water. It consists of a 6-ft. reinforced-concrete pipe, for the greatest

*Chronicle Bldg., San Francisco, Cal.

†See paper by R. D. Johnson, Proceedings of the American Society of Mechanical Engineers, June, 1908.

part of the length, and short connecting tunnels. The main consideration for determining the diameter of the pipe was that the average loss of head should not exceed 0% for the whole conduit. With 200 sec.-ft. flowing in a 6-ft. pipe the velocity is 200 ÷ 28.2743 = 7.07 ft. per sec. The loss in head is found as the slope s in the formula $Q = 200 = A\ C \sqrt{r\ s}$. The value of $A\ C \sqrt{r}$ from Kutter's formula tables, for a 6 ft. pipe with $n = 0.012$ is 4713.9; therefore $200 = 4713.9 \sqrt{s}$, or $\sqrt{s} = 0.0424$, which corresponds to a slope of 9.5 ft. per mile. Then the total loss in head in 40,000 ft., or 7.6 mi., is equal to 7.6 × 9.5 = 72.2 ft., or 6.54% of 1,104 ft.

The average loss of head should amount to about 5% for this part of the conduit, or 7.28 ft. per mile, which corresponds to a discharge of approximately 175 sec.-ft.

The secondary reservoir built at the entrance and the spacing for 25-ft. head is found to be 12 ins. for a unit-stress of 12,000 lbs. The tension in the concrete without reinforcement would be ½ × 72 × 10.82 ÷ 6 = 65 lbs. per sq. in., so that there would be a factor of safety without reinforcement probably between two and three. Possibly the unit stress in the steel could have been raised to 16,000 lbs. per sq. in. in this case, but to insure water-tightness the lower value is used, the spacing distance being already large. For 50-ft. head the spacing distance will be half its value at 25-ft. head, or 6 ins. For longitudinal reinforcement eight ⅝-in. square rods are used. The shape of the pipe is such as to offer the greatest resistance against the earth pressure with a minimum amount of material.

The cost of this pipe (not including excavating and back-filling), with concrete at $12 per cu. yd. in place, and steel at 6 cts. per lb. in place, would be:

For 25-ft. head: 12 cu. ft. concrete, 37.7 lbs. steel, = $7.60.

For 50-ft. head: 12 cu. ft. concrete, 64.8 lbs. steel = $9.21.

From a table of pipe costs at different heads, the actual location of the same is best determined; that is, the table will show whether it pays to cross a canyon by an inverted siphon, or stay on grade along the hillside.

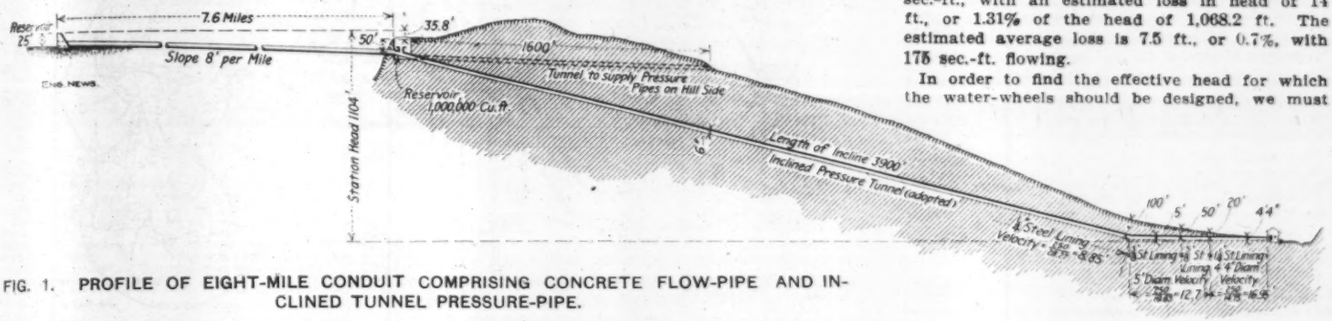

FIG. 1. PROFILE OF EIGHT-MILE CONDUIT COMPRISING CONCRETE FLOW-PIPE AND INCLINED TUNNEL PRESSURE-PIPE.

to the pressure-pipe proper is big enough to take care of one day's fluctuation, which may vary from 100 sec.-ft. to 250 sec.-ft. The supply is nearly constant, varying slightly with changes in water levels in primary and secondary reservoir.

The flow-pipe was given a slope of 8 ft. to the mile. With 200 sec.-ft. flowing, which we may have in emergency cases, a head at the entrance of 1.5 × 7.6 = 11.4 ft. would be necessary to force the full quantity through. With 175 sec.-ft. flowing no head at the entrance is required, the slope per mile required for this volume being 7.28 ft. per mile. The conduit takes the water from a small main reservoir, whose dam is 30 ft. high. The center line of the conduit is located 25 ft. below the top of the dam. This reservoir being kept practically full of water all the time, the head above the center line of the conduit will always exceed the necessary 11.4 ft.

The maximum head at the entrance is 25 ft. With a slope of 8 ft. per mile the maximum possible head at the end of the flow-conduit would therefore be 25 plus 8 × 7.6, or 85.8 ft. With water flowing at the rate of 175 sec.-ft. we have a pressure at the end of the flow-pipe due to the static head minus the friction head, or 85.8 less 7.28 × 7.6, which equals 30.5 ft. It would hardly be safe to use this pressure-head for the pipe calculation, as it is variable, but some pressure-head between this and the full static head must be chosen, say 50 ft. The corresponding pressure per square inch is 21.65 lbs. To guard against the possibility of the head ever becoming greater than 50 ft., the secondary reservoir is provided with an overflow at an elevation of 50 ft. above the center line of conduit at this reservoir. This brings the surface level of the secondary reservoir 35.8 ft. below the surface level of main reservoir.

With but little water flowing the friction-head may be less than this 35.8 ft., in which case head would have to be wasted by throttling the entrance gates or otherwise. In the case in question, however, this condition would never take place, as the water is to be used for irrigation after it leaves the power-house, and a certain amount must be kept flowing regardless of what is demanded for power.

The design of the flow-pipe is shown by Fig. 2. The pipe is reinforced with steel to resist the outward water-pressure. For the circular reinforcement ⅝-in. square twisted steel is used

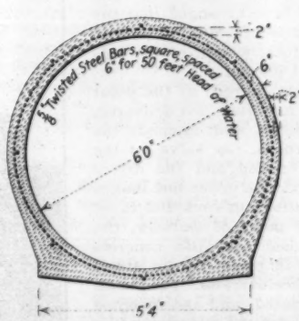

Fig. 2. Typical Section of Flow-Pipe (Pipe Completely Buried).

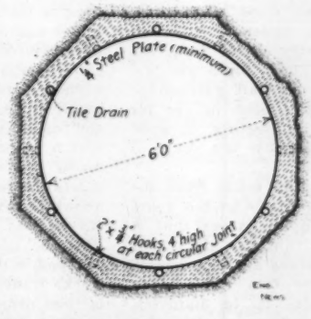

Fig. 3. Section of Upper Part of Pressure Tunnel.

the rest of the distance, the horizontal portion and the lower portion of the incline to be lined with steel, as might be determined later by examining the quality of the rock.

With steel at $200 per ton in place, tunneling at $20 per lineal foot, and the concrete backfilling (between steel lining and tunnel walls) at $12 per cubic yard, the cost of the inclined tunnel was found to be only half the cost of the other scheme. This saving is due to the fact that in the inclined tunnel the rock itself takes up the tension due to the water pressure, the upper part having a thin steel lining only for water-tightness where the rock is not absolutely solid.

Fig. 3 is a cross-section of the tunnel. As the layer of rock above tunnel decreases from say 200 ft. to nothing, the plate thickness is increased from ¼-in. to the full thickness necessary for withstanding the pressure above. At the same time the diameter is decreased to keep within practical plate dimensions, the least diameter being 4 ft. 4 ins. With a tensile stress of 12,000 lbs. per sq. in., 80% joint efficiency and (1,104 — 35.8) = 1,068.2 ft. static head, a plate thickness of 1¼-in. is required.

If the tunnel is not in solid rock, the heavy steel to withstand full pressure would have to be used. And precautions would have to be taken to be certain that no large hydrostatic pressure could be applied to the outside of the pipe when empty.

The maximum capacity of the pressure tunnel from secondary reservoir to powerhouse is 250 sec.-ft., with an estimated loss in head of 14 ft., or 1.31% of the head of 1,068.2 ft. The estimated average loss is 7.5 ft., or 0.7%, with 175 sec.-ft. flowing.

In order to find the effective head for which the water-wheels should be designed, we must first find the average elevation of water level in the secondary reservoir. With 175 sec.-ft. in the flow-pipe we have a drop of 55.3 ft., and if we make the assumption that the average water level in the main reservoir is 10 ft. below the top we have the average water level in the secondary reservoir 65.3 ft. below the top of the main dam. Adding to this 7.5 ft. head lost in the pressure-pipe, the effective head is found to be 1,104 — 72.8 = 1,031.2 ft.

Any small errors in the calculations and different assumptions can be corrected afterwards by changing the size of secondary reservoir. This reservoir cuts down the fluctuations in head due to friction loss in the flow-pipe from 72.2 ft. to 55.3 ft., and also cuts down its size, as the velocity of flow is high and nearly constant so that the pipe is worked close to maximum efficiency. The secondary reservoir also cuts down the maximum static head on the pressure pipe, in this case by 35.8 ft., without cutting down the effective head on the wheels; in fact it increases this head.

The total loss of head with 175 sec.-ft. flowing, 62.8 ft., is equivalent to 885 HP. at the switchboard. For economy the value of the energy annually lost in frictional resistance is approximately equal to fourtenths of the annual cost of the pipe line,* this annual cost being taken as 7.5% of the first cost. Thus with power at $20 per year 855 × 20 should be equal to 0.4 × 7.5/100 of the cost of the conduit, i. e., flow-pipe and pressure pipe. That is, $17,700 should equal approximately 0.4 × 7.5/100 (496,000 + $120,000), or $18,480, which checks very well.

Had an open gravity conduit been chosen, either flume or ditch, in connection with short pieces of tunnel, the same slope of 7.28 ft. per mile could have been used. In this case the highest possible water level in the secondary reservoir would be on the flume grade at this

*A. L. Adams, Transactions of the American Society of Civil Engineers, December, 1907, p. 177.

point, or 65.3 ft. below the crest of main dam, since the flume grade would be started 10 ft. below the crest of the main dam in order to be able to use this reservoir for regulation to some extent. How much lower the average water level in the secondary reservoir would be will depend upon its size, its shape (whether deep or shallow), and the load fluctuations. It might easily be 20 ft. lower, which would represent an average loss of 270 HP. at the switchboard. Besides this disadvantage, the open conduit does not allow any entrance head to force water through it; whatever entrance head may exist must be wasted in the outlet gates. Such an open conduit must, of course, be built for the maximum capacity at the chosen grade.

COST COMPARISON OF CONCRETE PIPE, TIMBER FLUME AND WOOD STAVE PIPE.

FIRST COST.

Reinforced-Concrete Pipe:	
40,000 ft. of reinforced-concrete pipe for heads from 25 ft. to 50 ft., average cost per lin. ft. ½ (7.60 + 9.21) = $8.40	$336,000
Excavating and backfilling (pipe completely buried), $4 per lin. ft.	160,000
Total	$496,000
Timber Flume:	
40,000 ft. wooden flume, with a carrying capacity of 200 sec-ft., at $5.50 per lin. ft.	$220,000
Excavating and grading, $1 per lin. ft.	40,000
Total	$260,000
Wood Stave Pipe:	
40,000 ft. of wood stave pipe 6 ft. in diameter, average cost per lin. ft., $6.50	$260,000
Excavating, 50 cts. per lin. ft.	20,000
Total	$280,000

ANNUAL COST.

Reinforced-Concrete Pipe:	
Maintenance, 1% of $496,000	$4,960
Depreciation, ¼% of $336,000	1,680
Interest and taxes, 6% of $496,000	29,760
Total	$36,400
Timber Flume:	
Maintenance, 4% of $260,000	$10,400
Depreciation, 4% of $220,000	8,800
Interest and taxes, 6% of $260,000	15,600
Total	$34,800
Wood Stave Pipe:	
Maintenance, 4% of $280,000	$11,200
Depreciation, 4% of $260,000	10,400
Interest and taxes, 6% of $280,000	16,800
Total	$38,400

COST OF THE DIFFERENT TYPES OF CONDUIT.—From the calculations of cost tabulated below it will be seen that the reinforced-concrete pipe requires a capital outlay nearly twice as great as the two other kinds of conduit, but that its yearly cost is about the same.

To choose correct average values for the depreciation and maintenance of flumes and wood stave pipes is exceedingly difficult. On power systems examples can be found of great variations in length of life of flumes and wood stave pipes:

1. At one powerhouse two wood stave pressure pipes 6 ft. in diameter, under 88 ft. maximum head, are used to carry water from the penstock to the turbines. These pipes are laid on top of the ground and are half surrounded with stone spalls. They have been in use for nearly ten years and are apparently in good condition and able to give another ten years of service.

2. The wooden flume carrying water from the diverting dam to the penstock is also ten years old, but is decayed to such an extent that it must be rebuilt entirely within the next four years. The maintenance charges are now heavy.

3. At another powerhouse two wood stave pressure pipes (red-wood) 5½ ft. in diameter, under 84 ft. maximum head, were installed three years ago; they are buried in clayish soil. Considerable vegetable matter has been allowed to grow along the line and the pipes have decayed in places to a considerable extent.

Where the country is adapted for ditch construction, ditches will be the cheapest, as depreciation is practically zero, and maintenance cost is lower than for flumes. We would have an additional loss of 270 HP. as compared with a closed conduit, provided a secondary reservoir is used; otherwise all conduits would be practically alike as far as hydraulic loss is concerned.

The concrete pipe can be completely buried and is therefore protected against snow and rolling boulders. The wood stave pipe should not be buried, and therefore lacks this protection. Nowadays the hydraulic conduit is the weakest link in a hydraulic power proposition, as, for financial reasons, it cannot be built in duplicate; therefore, the safest kind for the given case should be used.

Traveling Concrete Mixers.

A traveling concrete mixer which combines the functions of a mixer and a wagon is one of the recent developments in concrete machinery, and several of the machines are in use. The construction is shown by the drawings, Fig. 1, while Fig. 2 shows one of the machines in service.

A horizontal frame (A), forked or V-shaped in plan, has an axle and a pair of 36-in. wheels at the rear end, while the front end is supported by a single 11-in. wheel. To this end is fitted the tongue for a team of horses. On each side is a standard (B) carrying the bearings for the trunnions of a mixer of the cubical box type, having a capacity of ¼-yd. or ½-yd. Each trunnion has keyed upon it a 23-in. spur wheel (C) gearing with a wheel of the same size (D) on the carrying axle; the latter wheels can be connected to or disconnected from the axle by means of a clutch. On one side is a 16-gallon water tank, connected to a perforated pipe which passes through the hollow trunnions and extends across the mixer box. The ends of the pipe are plugged, and the receiving end has an iron sleeve to carry any leakage clear of the gearing. A glass water gage on the tank is graduated to show the amount of water required for each batch. The door of the box is so arranged that the mixer can be filled to 80% of its full capacity. The total weight of the machine is about 1,400 lbs.

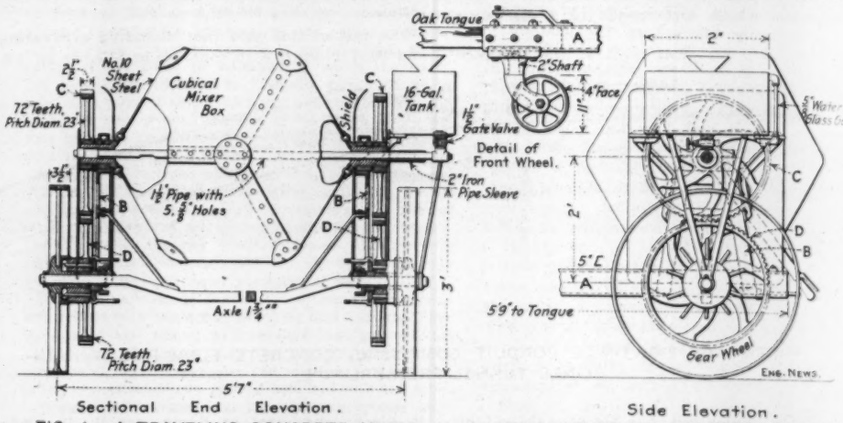

FIG. 1. A TRAVELING CONCRETE MIXER. U. S. STEEL MIXER CO., CHICAGO; MAKERS.

The machine is charged at the point where the raw materials are delivered, the door is closed and latched, the clutch is thrown in, the valve on the water pipe is opened and the driver starts the team. The mixer box makes about 11 revolutions in each 102 ft. of travel. At the point of delivery, the door is unlatched and the concrete dumped, either in place (as for street work) or into wheelbarrows. The clutch is then disconnected, and the machine returns empty, with the mixer standing still. About five men are required; one with the machine, two at the charging point to prepare the materials and fill the mixer, and two at the delivery point to dump and spread the concrete.

One of the advantages claimed is in the small number of men required and the large amount of concrete delivered per man per day, this averaging about 10 cu. yds. for a 10-hour day. To facilitate charging, the materials are shoveled into measuring hods, which are quickly dumped into the mixer. Another advantage is that there is no handling of the raw materials by wheelbarrows to charge the mixer, and in many cases (as on street work) no handling of the concrete by wheelbarrows to distribute it in place.

The machine is considered to be specially suitable for jobs where the installation of a power mixer and its equipment of wheelbarrows, scaffolding planks, etc., would be inconvenient, as may be the case in laying the concrete for a street foundation. It is also of advantage for small jobs, where the transportation and setting up of a power mixer and its equipment would involve an expense out of proportion to the cost of the work, besides requiring a larger number of men than is required with the traveling mixer. It has been used, however, on jobs of varying size, for street work, buildings, etc. It is the invention of Mr. S. N. Cornwall, President and General Manager of the U. S. Steel Mixer Co., Atwood Building, Chicago.

In its general features the machine is similar to a traveling mixer brought out some years ago by Fisher & Saxton, of Washington, D. C. This earlier machine, which was described and illustrated in our issue of Sept. 6, 1900, had no gearing, but its mixer was a cylindrical drum which was mounted on the axle and could be connected to the wheels so as to revolve with them. The drum had a door for filling, and was dumped by opening the drum across its horizontal diameter, and swinging the lower half to an inverted position. Only one horse was used.

Another horse-traction concrete mixer, built by the Burrell Mfg. Co., of Bradley, Ill., has a horizontal cylindrical drum driven from the carrying wheels by means of a ratchet and differential gear. The drum is 3½ ft. diameter and 4½ ft. long, with a capacity of 10 cu. ft. Its shell is spirally formed so as to give a longitudinal slot or opening 7 ins. wide for loading and dumping; in this way it distributes the concrete over a width of 4½ ft. The makers state that one machine, handling 7-yd. batches, will mix and distribute 155 cu. yds. in a 10-hour day, or 310 sq. yds. of 6-in. street foundation. The machine weighs 1,800 lbs. and is handled by two horses.

FIG. 2. THE TRAVELING CONCRETE MIXER IN SERVICE.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
SAN FRANCISCO: Monadnock Building
ATLANTA: Candler Building
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A very curious accident occurred recently at the noted Y-bridge over the Fraser River, New Westminster, B. C. It emphasizes the well-recognized fact that switches and similar weak points in track should be avoided on a bridge structure. We noted the accident briefly in our record of the week's railway accidents, June 24, but together with fuller facts sent us since then by a Puget Sound correspondent the case merits repeating.

The north end of the Fraser River bridge* is forked or spread, to accommodate two diverging tracks. The northerly span, 225 ft. long, has two trusses, spaced 19 ft. apart at the river end and 136 ft. apart at the land end; the floor-beams, plate-girders, vary in span to suit the distance between trusses. The lower lateral system of this span is not continuous, but distributed so as to stiffen both the trusses and the floorbeams sufficiently. There is an upper deck for highway use, which does not concern us. The lower deck of the bridge carries a single track which at the narrow end of the spread span branches to east and west. The diverging tracks are on sharp curves.

The accident occurred at the switch where the single track branches. A westbound Great Northern train on its way to Vancouver crossed the bridge at about 6 a. m., June 22. It should have turned off on the right-hand branch, the left-hand branch being the route of an electric car line. Reports say that the switch was "open," or "misplaced"; at any rate the locomotive was derailed at the point of divergence and continued ahead in a straight line, and, as the flooring diverged away to either side, fell through the open space between floorbeams and laterals. As it broke away from the train, the air-brakes went into action and held the rest of the train in safety, but the engine with its crew disappeared in deep water.

Reports speak of the "watchman" failing to notice the condition of the switch. If a switch is a weak point in railway track, it would of course be better to avoid switches altogether in such specially hazardous locations as on bridge track. This is not always possible; both viaducts and river bridges frequently must have turnouts, cross-overs, or the like. But in such cases, we hold, the very best protection available should be provided at these points. Automatic switch-protection apparatus of the highly-developed types now current, which have proved their serviceability in complex, heavy terminal service, should by all means find application there. The insufficiency of watchman protection, as compared with automatic protection, was shown for example by the disastrous Thoroughfare Draw wreck of the Pennsylvania R. R. at Atlantic City a few years ago.

*An illustrated description of the structure appeared in our issues of June 15 and 22, 1905.

The crude ideas on municipal health-protective work still held in many parts of the country are well illustrated by the spasmodic campaigns for a general clean-up of dirt and litter which are reported from various quarters. When the dirt in streets, back yards and cellars gets so deep as to be a serious impediment to locomotion and the air is so filled with fragments of flaring metropolitan Sunday newspapers and scraps of building paper that the inhabitants have difficulty in spying on their neighbors, then some amateur board of trade or some woman's club enlists the local weeklies in a grand cleaning-up campaign.

The only fault to be found with these clean-ups is that they are too infrequent and that they serve to lull into a false sense of security sanitary consciences already far too dull. The clean-up campaigners, the local press and the public all make much of the beneficial effect of a yearly dirt removal on the public health. As a matter of fact, these clean-ups, even if far more frequent, have little effect on general health and still less on the prevalence and spread of specific infectious diseases. Furthermore, spasmodic dirt removals may do very positive harm when held up to the public, as they generally are, as highly beneficial sanitary measures. In such cases, attention is diverted from instead of directed to the real health-protective work needed in the community, which is the constant, never-relaxing watch set over *all* of the avenues by which infectious diseases spread from one person to another. The most important of these are the public water and milk supplies and direct and indirect personal contact between sufferers and non-sufferers from cummunicable diseases. The control of the spread of disease from one person to another demands a judicious isolation of patients suffering from some of those diseases and the disinfection of their clothing and other articles of use, as well as the rooms which they have occupied during illness. All these safeguards—sanitary control of milk and water supplies and of infected persons and things—are generally sadly lacking in villages, towns, most smaller and many fair-sized cities; and particularly so in those which rely upon spasmodic clean-ups for the removal of ordinary dirt and rubbish.

Promptings for the foregoing remarks originated in glowing statements regarding a grand clean-up recently organized in a small city of the South. We have since been somewhat puzzled by announcements of a "Clean City Day" for no less large and proud an American city than Pittsburg, Pa. After due advertisement, the day came and, it appears, proved so utterly insufficient a period that it had to be extended to six. During this week it is reported that some 30,000,000 lbs. (some people and cities like big numbers even if small units have to be chosen to make them up) of dirt were removed, largely from cellars and yards.

One would have supposed that so large and generally progressive a city as Pittsburg would not require a clean-up day—much less a whole week—in this year 1909. The facts seem to be, however, that Pittsburg, with its enormous growth in polyglot population, has not been able to keep pace with all its municipal needs. It must be credited for giving first attention, after long and seemingly inexcusable delays, to securing a pure water-supply and to carrying on many health-protective efforts, through its health department, that are of infinitely more importance than transferring ordinary dirt from yards to dumps.

In the present unfortunate state of public ignorance as to what is most vital to municipal health there is some excuse for making a flourish of trumpets in an occasional anti-dirt campaign. Dirt piles and rubbish heaps are something tangible and some of them may be actual sources of infection. Creating a sentiment against accumulations of dirt or arousing feelings perhaps long dormant, opens the way for campaigns against less tangible but more dangerous enemies to the public health. Therefore special municipal and private house-cleaning days should be encouraged, in the hope that they will lead to a state of continuous cleaning and permanent cleanliness and from this on to still more important and efficient health-protective measures.

Why do not railways put the names of their stations in a place where they can be seen by the average passenger on a passing train? In the vast majority of towns and smaller cities in this country the name on the railroad station is at one of two places, either hanging from the track edge of the station roof some few inches from the roof of a car on the near track and therefore absolutely obscured from the eye of the passenger, or else on the end of the station platform where only those in the front or rear cars may see it, and then only when the train is stopped. In a number of cases, especially in the larger cities, there are no signs at all.

Obviously those familiar with the place do not need such signs; they are only for the benefit of the stranger who, as a rule, is on the incoming or passing train when he needs them most. It would seem, then, to be the duty of the railway to make recognition easy for this stranger. In addition the advertising value of well-placed signs should commend itself to the business men of the city. A large sign well back from the tracks might often serve to mark the name on a passenger's mind to the ultimate benefit of a town which unmarked would have been to the passenger a mere collection of houses and streets, soon to fade from memory, or never to be recalled to any useful purpose.

We had occasion last week to speak against the inactivity of certain technical societies in the matter of recognizing concretely the public duty of the profession toward the public. The American Institute of Architects and the American Society of Civil Engineers were mentioned specifically. An incident of the past week reminds us, however, that the Architects on many occasions have been quite prompt and energetic in making appearance for their professional interests before the public, before law-making or judicial bodies, and the like.

The building superintendent of one of the boroughs of New York City was summarily dismissed by his superior, the Borough President, for a trivial reason. The superintendent had just suspended one of his subordinates who, it later developed, was a special protégé of the Borough President. The latter official (elected by the people) was himself under investigation, and some of the testimony indicates that he lorded it over the Building Superintendent's office as his special preserve, naming its subordinate appointees and virtually putting them over the head of the Superintendent. In the case of so important a department as that of building supervision these are obviously menacing conditions, quite apart from any question of the character or fitness of the superintendent himself. But it seems also that the latter was fairly efficient and well-behaved. At least this is the expressed opinion of the local chapter of the American Institute of Architects. That body felt its professional interests injured by the abrupt dismissal of the Superintendent of Buildings, especially under the suspicious circumstances of the case. It, therefore, made an official written protest against the removal, which spoke of the satisfactory relations between the local architects and the superintendent's office.

Official and authoritative action of this kind is of great weight. Public approval and criticism, and (in certain cases) disinterested expert advice from public bodies, are very powerful regulators of political life. The architectural organizations have been fairly vigilant in doing their part of the citizen's duty in this direction. The above little incident, together with many previous public appearances made by such bodies, illustrates this, and leads us to withdraw in part the implied criticism contained in our remarks on the defeat of the threatened new New York Building Code, in our last issue.

As against the Civil Engineers, however, our criticism gains in force. When we see that other technical professions are active to defend their interests as professional men and as citizens, we must wonder at the almost total silence and inactivity of engineering societies. Yet their work and their knowledge and interests touch the public interest at a far greater number of points than do those of the architects. Under the circumstances, one is tempted to accept the oft-repeated complaint that engineers are delinquent in citizenship, and that an awakening is necessary to stir them into action.

Elastic Limit or Yield-Point as Guide for Working-Stresses?

What value has the limit of proportional deformation, the "true elastic limit," of any material to the engineer or designer who has to deal with that material? The question is serious rather than trivial, since it concerns a respectable fraction—10 to 20%, and in some exceptional cases much more—of the total utilizable strength of material. There is little or no experimental evidence to answer it definitely, or at least there has been no full analysis of the available experimental data. The prevailing tendency is to regard the "true elastic limit" as the ultimate limit of safe stress, but this view seems to have come into being somewhat surreptitiously and not by actual proof of fact.

We may call to mind in this connection that, after a persistent campaign by the small band of laboratory investigators of materials, fairly general acceptance has been secured for the term Yield-point in place of the old term Elastic Limit. In tests of wrought-iron and ordinary steels, the point at which the scale-beam drops and cannot easily be held in balance is now called Yield-point, and we have relegated the name Elastic Limit to another and lower stress. Thus, in a given test the drop-of-beam or the sharp bend of the strain diagram may be found at a load of 32,000 lbs. per sq. in., while the first curving away from a straight line may occur at perhaps 26,000 or 27,000 lbs. per sq. in.; this latter point we now call the elastic limit.

For many years past, increasing importance has been attached to the elastic limit as a guiding-point in fixing permissible stress-intensities. In an earlier period the ultimate strength was the sole criterion of safety. But after a time it was recognized that most structures would be virtually wrecked, and some would collapse altogether, when any of their parts was stressed enough to give it a perceptible, lasting stretch. Thereupon the Limit of Elasticity came more into notice as a guiding-point.

Furthermore, ingenious and patient tests of metals under oft-repeated loading gave a distinct hint that actual rupture is liable to occur even at stresses far below the "ultimate strength," if the stress be released and repeated many times. And it seemed that this effect would occur in time under any stress beyond the limit of elasticity; i. e., under any stress which, acting once only, produces a permanent set. This conclusion is still accepted in full, although the early name of "fatigue" is no longer in favor.

Thus it became common practice, in time, to judge stress-intensities by the elastic limit of the material instead of by its ultimate strength. At this time, however, most people thought only of that limit which we now prefer to call the yield-point, in other words the load at which the knee of the stress-strain curve appears or where the scale-beam of the testing-machine drops. In fact, this point was generally considered to be the limit of perfectly elastic behavior, the point up to which the distortions remain exactly proportional to the applied loads and no distortions are produced which do not disappear on removal of load. The principle that the safety of any given loading must be judged by the elastic limit of the material was taken to refer to this point. However, a number of laboratory investigators knew well, through all this time, that the exact proportionality of distortion to load ceases before the drop-of-beam load is reached. And some of them, we believe, early claimed that this lower point, the true limit of proportional deformation, should be the guide in judging stress-intensities.

In the more recent transition from "elastic limit" to "yield-point," and the adoption of the name "elastic limit" for the lower figure (where the stress-strain line first begins to curve), this latter view has also come to wider acceptance. There has been a growing tendency to take away from the yield-point every vestige of importance, transferring all its functions to the "true elastic limit." To-day the prevailing view is that the "true elastic limit" is the virtual limit of strength of a material, and that a working-stress of 16,000 lbs., on steel whose yield-point is at 32,000 and limit of proportionality near 27,000 lbs. per sq. in., leaves us a safety-margin of only 11,000 instead of 16,000; in other words, that the factor of safety is only 1.7 instead of 2.0.

In so far as this belief leads to more conservative stress-intensities, it is perhaps a useful belief. Many things are constantly exerting pressure to raise the allowable stress figures, and few tendencies act in the other direction. It may be harmless, then, to accept an argument whose effect is to hold down the limits of stress and prevent their further rise—for in some fields of construction they have risen continuously. But this is at best a plea, rather than an argument. It does not bear on the question of fact.

It seems to us that the shift of attention from the former Limit of Elasticity or the yield-point to the present elastic limit has gone along with too much tacit acceptance and without sufficiently rigid question as to the real meaning of these two points. Though there was much opposition to adopting the new term yield-point, it was a quarrel over names only, and when the progress of time and the influence of technical schools brought the new terminology into the ascendant, the opposition weakened and stopped. The real point at issue, namely, whether—conceding its existence—the limit of proportionality or "true elastic limit" is after all a point of much importance, has remained practically undiscussed. The question merits discussion, we submit.

The question may be put thus: Is material permanently injured by a stress beyond the limit of proportionality; or, better, What is the minimum stress at which material suffers permanent injury? The question looks simple, but it seems to us rather complex, even when restricted to ordinary steels and wrought-iron, without reference to the larger class of materials where no "limit of proportionality" can be fixed. We would resolve it into three simpler questions, and ask answer to them:

First: Does permanent set begin at the same load as marks the end of strict proportionality of deformation? An affirmative answer to this is probable, or plausible, but not at all obviously necessary. The two points in question are rather delicate of determination, and therefore the accuracy of the experimental results cannot be very high. If in reality they always lie near together, the experimenter might easily be led to conclude that they actually coincide. But the records of experiment are quite erratic.

Second: Is the limit of plastic recovery identical with the limit of elastic recovery? The point of first permanent set as determined in the testing-machine is that at which the material does not promptly return to its initial dimensions. Most materials, however, have some slight power of slow recovery, or plastic elasticity. It is quite possible that the initial fraction of the "permanent set" ordinarily determined is not lasting, but will disappear after a time of rest. If this be the case, such temporary set should probably not be regarded as permanent injury of the material, at least for some classes of service.

Third: As to the limit of endurance under repeated stress, where is this located with reference to the other "elastic limits" of the material. Let us assume, for example, in the absence of proof of the opposite, that the several points above referred to are all different: (a) limit of proportionality, (b) limit of immediate elasticity, (c) limit of plastic elasticity, and (d) yield point. Then we ought to find out which of these points, if any, determines the limiting load for endurance under continuously repeated loading. In those kinds of service where the material is exposed to rapidly repeated applications of stress, this last is the real point of importance, since "permanent injury," or weakening, is most accurately defined as a condition which renders the material less able to resist a repetition (or many repetitions) of the same stress.

When these questions are answered, we will know whether it is proper to regard the "true elastic limit" as the gage-point in fixing working-stresses. Until then, however, this at present popular view must seem rather unwarranted. It may be conceded that in some kinds of structure, as in long columns, the limit of proportionality of the material is highly important, because a change of elastic modulus occurs at this point and as a result the distribution of stresses, etc., is altered. But for general use this consideration does not enter, and here, until proof of the opposite is at hand, our own judgment leads us to attach chief importance to the "yield-point," as was done formerly.

LETTERS TO THE EDITOR.

The Action of Smoke-Gases on Setting Concrete.

Sir: I note in your issue of July 22, p. 102, an article on disintegration of fresh cement floor surfaces by the action of smoke-gases at low temperatures, by Mr. White.

He cites the case of a thick layer of dust on the surface of the cement finish, using granite. He will get the same results under the conditions he notes with or without the smoke. The reason, as the writer looks at it, is as follows: At lower temperatures the cement sets slowly. It is necessary to wait six or eight hours before the polishers can finish up the wet mix top coat; result, the cement has partially obtained its initial set, the finish breaks it up, injures the cement, brings to the surface the feld-spar dust and it never hardens but leaves a thick coating of dust. Carbon dioxide, so far from injuring the cement in setting, seems to improve it, as far as the writer's experience goes in observing hardening of concrete where artificial heat has been supplied by salamanders using coke, the gas and smoke being so thick that it would not be safe for a man to remain long exposed to it.

The trouble with the finish coat referred to in the article appears to the writer to have been largely a matter of inexperience in handling the concrete.

Yours truly, C. A. P. Turner.

Phoenix Bldg., Minneapolis, Minn., July 24, 1900.

The Early History of the Chicago Drainage Canal and Present-Day Justification for Sewage Disposal by Dilution.

Sir: In your editorial remarks on the interesting story of the Chicago Drainage Canal told by Mr. Isham Randolph, Chief Engineer during the most important period of the construction, you say "It has seemed worth while . . . to present a connected story of the Drainage Canal *from its inception*" (the italics being mine). "Inception" would mean its incipient or initial stage, but Mr. Randolph begins the story with the election of the first Board of Trustees, Dec. 12, 1889, created to carry out the present plan. Construction work was then begun, but the general plan had been under consideration for at least 20 years before, which should mark the date of inception.

Mr. E. S. Chesborough, Past President of the American Society of Civil Engineers, and for a number of years city engineer of Chicago, was the first official to seriously suggest the drainage canal to the Desplaines River as a proper future solution for the sewage disposal question in Chicago. After numerous spasmodic agitations, the Citizens' Association in 1884 issued a pamphlet in which this plan was again moved to the front and, with the aid of Mr. L. E. Cooley, M. Am. Soc. C. E., along more definite lines than ever before.

The importance of the water-supply and sewage question now became a pressing one on account of the pol-

lution of the former. Serious disagreements arose as to the better of two plans: namely, as to whether the sewage should be returned to the lake purified, or whether it should be diverted into the Mississippi Valley with possible dilution, and incidentally establish a large water-way from the Great Lakes to the Mississippi River. Mayor Harrison was authorized to appoint a commission of engineers to decide the question, and selected as chief engineer the undersigned, then assistant in the Philadelphia water department. Mr. Benezette Williams, M. Am. Soc. C. E., and Mr. Wm. G. Artingstall, M. Am. Soc. C. E., were associated with him during the latter part of the work. A year's work with a large force witnessed the study of the feasibility and cost of intermittent filtration on the sandy territory south of Lake Michigan, chemical precipitation, dispersion and dilution in Lake Michigan, and last, but not least, the Drainage Canal substantially as now built.

The report* was presented in January, 1887, and the recommendation was adopted.

Legislation to carry out the projected work was immediately sought and was finally obtained in 1889, when Mr. Randolph's interesting story of construction begins.

The undersigned deeply felt the great responsibility resting upon him and widely consulted European as well as American experiences. His decision was based not only upon the financial aspect, but upon the clear conviction that when properly arranged the disposal of city sewage by dilution in definite proportions, with water holding oxygen in solution, was as rational, as effective and as permanent as the disposal by purification on land.

As this conclusion is still occasionally antagonized by some prominent but misinformed laymen, to the injury of the interests of the general public, a frequent reiteration does not seem superfluous.

Whether sewage is purified on land or in water, purification is in both cases accomplished by oxidation, and disease germs are destroyed by starvation or sterilization. It is by no means certain that they are starved more effectually on land by modern sewage oxidation beds, rich in pabulum, than by dilution in oxygen-saturated running water, poor in pabulum.

In the case of dilution, after screening and dispersion, the sewage can, by immersion at the outfall, at once be made inoffensive and remain so, a very desirable result in a large city with extensive suburbs. In the case of purification on land, every economical method requires, for large cities, the condemnation of a strip of land surrounding the works to prevent any possibility of disagreeable odors inevitable in every economical large-scale process now known, from reaching private property. On the other hand, purification on land is rapid and allows the sewage to leave the works at once in a permanently satisfactory condition, while oxidation in water, owing to the smaller quantity of oxygen available in water than in air, is correspondingly slower. The latter method, however, where available, will always be preferred because of its simplicity, its immediate removal of all offensiveness and its economy.

This view is held by experienced practical engineers not only in this country, but also in Europe. Mr. Maurice Fitzmaurice, M. Inst. C. E., Chief Engineer of the London County Council, has recently so expressed himself and the chief engineers of several German cities, situated on large rivers, are of the same opinion.

In Liverpool and Birkenhead, crude sewage of about 800,000 persons is satisfactorily discharged into the River Mersey; in Bristol and Belfast the crude sewage from about 300,000 persons in each city is satisfactorily discharged respectively into the River Avon and the Lough. In Hull the crude sewage of 240,000 persons is discharged into the River Humber. In Hamburg and Altoona the crude sewage of about 1,000,000 persons goes into the River Elbe. Cologne, Dusseldorf, Magdeburg and Dresden also satisfactorily dispose of their sewage by dilution into the Rhine and Elbe and nothing is or is intended to be done by the engineers in the above-mentioned cities in the way of purification, except screening, which is done in most cases, and should be done everywhere. Our own cities, where it is feasible, are naturally following along the same lines.

Yours very truly,

Rudolph Hering.

170 Broadway, New York City, July 23, 1909.

[We commend Mr. Hering's remarks on sewage disposal by dilution to the attention of all who fail to recognize that water disposal may be as legitimate a method of getting rid of sewage as is land disposal.—Ed.]

Necessity of Caution in Constructing Hydraulic-Fill and Other Types of Earth Dams.

Sir: Anent the Necaxa Dam failure in Mexico, your excellent editorial in Engineering News of July 15, 1909, leaves but little to be said on the subject of using large quantities of nearly pure clay for the core of hydraulic-fill dams. Many hydraulic engineers have recognized the dangers incident to the use of clay, either nearly pure or mixed with fine sand and silt. Not only do clay cores of this class of material consolidate with great slowness, if at all, but they are always liable to become re-saturated from impounded water, and thus lose cohesion to the degree of producing a slide.

In connection with two different earth dams in California, for which the writer has been wholly or in part responsible, it was decided not to use the hydraulic-sluice method, after making a thorough investigation of the subject and careful tests of the materials as they would be segregated and deposited from sluices. It being deemed important that the materials to be deposited as puddle should consist of clay mixed with coarse crystalline sand and gravel in proper proportions, a semi-hydraulic-fill type of construction, which would accomplish this end, was adopted.

In the dam for the Mill Creek No. 3 Reservoir of The Los Angeles Edison Co., constructed near Redlands, Cal., the material was loosened by blasts from the hillside above the dam, and carried in Fresno scrapers to the two slope embankments. The material thus secured consisted of large rocks, gravel, coarse granitic sand and clay. By raising the two embankments high above the unfilled depression along the central axis of the dam, the slope could be maintained so steep that a hydraulic jet played on the inside of the bank would carry the clay, coarse sand, and some gravel down to the core.

Tests made with a sluice from the quarry site failed to produce such a beneficial result, and deposited far too much clay and very fine sand in the core. This fine material was tested and did not possess one-fourth the resistance to percolation or flowing currents of water, which the clay with coarse sand and a little gravel was found to possess.

An example of a hydraulic-sluice dam, deficient in this respect, is found in the Crane Valley Dam, Fresno County, Cal. This dam has a core of clay mixed with fine sand in such quantity as to form a considerable proportion of the whole mass. If this mass ever did consolidate, it has become resaturated and has completely lost its bond, so that water from the reservoir penetrates it readily and always stands in the core to the same level as in the reservoir pond. Material extracted from the core resembles a mixture of quicksand, fine silt and clay, and lacks the coarse particles around which these fine substances may consolidate.

It is needless to say that this dam is a failure. It has required frequent and expensive repairs, and has at times been saved from total failure in the nick of time. It is true that there were some springs in the foundation, which have also menaced this dam, but this has only been an added source of trouble, and does not alter the facts above stated in regard to the hydraulic-filled core.

The Arrowhead Dam, at Little Bear Valley, San Bernardino County, Cal., is being constructed in much the same manner as was the Mill Creek No. 3 Dam, the principal difference being that the material is transported in dump cars instead of by scrapers, a difference in the conditions met and the magnitude of the work having made this necessary. The results being obtained at Arrowhead are satisfactory in every way, as sufficient coarse sand and gravel moves along with the clay and silt to produce perfect solidification.

The writer's experience with these two dams has demonstrated another decided advantage of the track-bank and jet-hydraulic process, or semi-hydraulic-fill method of construction. This advantage consists in using less water than is required in carrying-sluices, because a jet under pressure does more effective work with only a fraction as much water. Therefore, a surcharge of the core is avoided, and the drainage occurs quickly, being followed by rapid and perfect consolidation.

The Arrowhead Dam has a concrete core-wall from bed rock in addition to the puddle core, and this brings us to another very important subject. The writer has always believed that any type of earth dam must be of limited height, unless it has a masonry core-wall, and the Arrowhead Dam is 200 ft. high.

Now, it must be obvious that a core of consolidated clay loses its value, whenever the hydraulic pressure against it becomes too great. To meet this danger the base of the clay core in the Necaxa Dam was apparently made very thick, and as a result the clay body was so large it did not drain out and the slide occurred.

In this case it proved impracticable to construct a clay core so thick that it would resist a water pressure approximating 200 ft. head. Had the core been made of less thickness, it might have been built successfully, but it would have failed under the full reservoir pressure, sliding down the canyon instead of into the reservoir.

Thus, it seems to the writer that to dispense with a masonry core-wall in hydraulic-fill earth dams of such height places one between "the devil and the deep sea." All the experiments made and the experience had to date does not present a solution of the problem, which can cause an engineer to feel safe in constructing that kind of a dam with the materials ordinarily found at sites like the Arrowhead and Necaxa.

Again, the construction of earth dams on bed rock, without having a fairly resistant masonry core-wall, is at best a dangerous experiment. There is every inducement for the water to follow the bed rock and for the dam to slide. This applies to low as well as high earth dams, but for a height near 200 ft. the risk amounts almost to certain failure.

Respectfully yours,

F. C. Finkle.

Los Angeles, Cal., July 22, 1909.

*This report has recently been reprinted by the International Waterways Commission as an appendix to its report of 1907.

Notes and Queries.

An addition to the article on "A Railway Transfer Table Without a Pit," published in our issue of July 15, 1909, was received from the author too late to be included in the article as published. The additional paragraph is as follows and concerns the winding drum by means of which rolling stock is drawn onto the table:

As there is not room for the drum between the tracks on the table, it is located with its axis parallel to that of the table and it is necessary to pass the cable over a sheave in order to lead the cable to either end of the table. The sheave is so close to the drum that were the drum stationary the cable would not wrap properly on the drum. To correct this, the drum in winding or unwinding travels on a screw the pitch of which equals the diameter of the cable, thus always maintaining a straight lead from the drum to the sheave.

The screw upon which the drum is mounted is clearly indicated in Fig. 2 of the above named article. Transfer tables of this type are now being put on the market by G. H. Nicholls & Bro., of Chicago, Ill.

IMPACT TESTS ON BRIDGES have been conducted on an extensive scale under the direction of the Committee on Iron and Steel Structures, of the American Railway Engineering and Maintenance of Way Association. In Bulletin No. 112 (June, 1909) there are about 60 pages of diagrams and tables of the results of a large number of tests made on bridges of various types and spans to determine the deflections under varying conditions of traffic loads and speed. There is no analysis of the tests or results, as this material is simply matter for information accompanying a progress report of the committee. As to the influence of speed, however, there is the following brief statement:

It was repeatedly observed in the case of spans of considerable length that the greatest vibration was caused at a speed at which the rate of rotation of the locomotive drivers corresponded closely to the natural rate of vibration of the loaded structure. This may be called the "critical speed." For speeds higher than such "critical speed" the vibrations were less, and for speeds lower than such speed they were also less. The critical speed is obviously not the same for all structures of the same span length, being lower for light structures having large deflections and higher for heavy structures with small deflections.

THE FUTURE TIMBER SUPPLY of the United States has been made the subject of a circular issued by the U. S. Forest Service. We quote from the circular a convenient and telling summary of the bulletin, as follows:

As is shown in the preceding pages, the total yearly drain upon our forests, not counting losses from fire, storms and insects, is some 20,000,000,000 cu. ft. Our present forest area of 550,000,000 acres may be roughly estimated to consist of 200,000,000 acres of mature forests, in which the annual growth is balanced by death and decay, of 250,000,000 acres partially cut or burned over, on which, with reasonable care, there is sufficient young growth to produce in the course of time a merchantable, but not a full crop of timber, and 100,000,000 acres of more severely cut and burned-over forests, on which there is not sufficient young growth to produce another crop of much value.

Taken as a whole, the annual growth of our forests under these conditions does not exceed 12 cu. ft. per acre, a total of less than 7,000,000,000 cu. ft. That is, we are cutting our forests three times as fast as they are growing. There is menace in the continuance of such conditions. While we might never reach absolute timber exhaustion, the unrestricted exploitation of our forests in the past has already had serious effects, and it will have much worse if it is allowed to continue unchecked. White pine, for instance, which was once considered inexhaustible, has fallen off 70% in cut since 1890, and more than 45% since 1900. The cut of oak, our most valuable hardwood lumber, has decreased 16% since 1900, and that of yellow poplar 22%. The same story will be told of other woods if they are not conserved.

The fact that timber has been cheap and abundant has made us careless of its production and reckless in its use. We take 250 cu. ft. of wood per capita annually from our forests, while Germany uses only 37 cu. ft., and France but 25. On the other hand, Germany, who has learned her lesson, makes her state forests produce an average of 48 cu. ft. of wood per acre. We have as fast-growing species as Germany, or faster, and as good or better forest soil if we protect it.

The necessity for more farm land may eventually reduce our total forest area to 100,000,000 acres less than it is at present. It is entirely possible, however, to produce on 450,000,000 acres as much wood as a population much greater than we have now will really need if all the forest land is brought to its highest producing capacity and if the product is economically and completely utilized. But to reach the necessary condition of equilibrium between timber production and consumption will take many years of vigorous effort by individual forest owners, by the states, and by the National Government. None of them can solve the problem alone; all must work together.

A High Record in Bricklaying Attained by Novel Methods.

By L. W. PECK.*

High records in bricklaying were attained a short time ago in the construction of six brick buildings for Atwood & McManus, box manufacturers, at Chelsea, Mass. By the use of interesting special methods, a remarkably large output per man and a low cost per thousand were reached. At times individual records at the rate of 3,000 brick per day were made, and on the last two days of the contract the entire bricklaying gang *averaged* 2,600 bricks per day per man; this last was on 12-in. walls, jointed both sides.

A short description of the methods follows. The graphical records of performance mentioned in this article were under the personal supervision of the writer, who was in charge of the cost analysis for the general contractor, Frank B. Gilbreth.

In order that the reader may note the process that more than doubled the output, it will be well to start with the arrival of brick on the job. Carload lots of face and common brick, about equally proportioned, were set in on the spur track on one side of the job. Different methods were used in unloading the brick. From one to six men were tried on a car and their work carefully recorded. It was found that one man could unload a car much cheaper than two or more men, provided his individual record or output was recorded, but it was necessary to have six or eight men in each car because the siding was not long enough to accommodate more than three cars, and the brick were being laid as fast as unloaded in some cases. This also saved demurrage.

Charts posted on the field office wall showed the men holding high scores in unloading. Every man wore a button showing his number in large figures. A spirit of rivalry was created, and men on this work needed no other watching than recording their outputs, knowing their record would be marked up as soon as the car was empty.

"PACKETS" IN PLACE OF HODS.—Special carriers called "packets," holding 18 brick, were used exclusively on this work. These are simply rectangular frames of 1 × 2-in. strips, 8½ ins. wide and about 30 ins. long, accommodating 18 bricks in two tiers, on edge. They stack readily, whether full or empty, and are convenient to handle. The view Fig. 1 shows a number of empty packets, while in Fig. 2 they are seen as piled on the special barrow mentioned farther on, and in Fig. 3 on the staging.

The men unloading cars sorted the brick and piled them on packets. Packets of exterior and filling brick went onto the wall in different wheelbarrows, and picking over or culling a pile of brick by the masons on the wall was in this way eliminated.

Gravity conveyors were used between cars and storage sheds. These are something like unloading skids in form, and consist of ball-bearing steel rollers set in a frame of bar iron. In the case of two of the buildings, the conveyor carried packets from the car door direct to the elevator. This was as nearly an ideal condition as could be wished. One man taking packets from the conveyor and loading wheelbarrows kept the elevator supplied, which in turn supplied the masons. The highest records on brickwork were made where this arrangement was used.

The fact that the brick were handled in units of 18 only, up to the time the mason laid them, was but one of the advantages in the use of the packet. Its other important advantages will be realized on considering the time necessary to load loose brick into a hod, carry onto staging and dump, not to mention the time lost by the mason when looking for a certain kind of brick in a disorderly and badly mixed pile, of which many bricks are chipped. Reports of production on packet-handled brickwork demonstrated the economy as compared with ordinary brick hods.

Tests which proved that units of 90 lbs. were the most economical to handle decided the question of how many brick should constitute a packet. The precise position of the packets on the staging for best performance was determined by actual trials, and careful comparison of the times required to lay brick. At first the packets were set parallel to the wall, on the theory that the shortest distance from packet to wall should be the determining factor. It was soon found that other factors played a more prominent part, so all packets were placed at right angles with the wall. As there were two piles of brick, face and common, this arrangement made it easy for the mason to reach all the brick all the time, with his wrist normal to the brick—the most natural position. The packet plan of unloading and handling gave the mason the kind of brick he wanted when he wanted them.

All packets were painted black on one end. When brick were put on packets, on edge, the

Fig. 1. A Truckload of "Packets" on Way to be Reloaded.

natural top of each brick was placed toward this end. This arrangement of packets on scaffold or floor saved the mason turning brick over, or tossing aside on account of being chipped, etc.

Mortar boxes were spaced exactly 3 ft. apart on the staging. Packets were set flush against the left-hand side of the box as the mason faced it, leaving space for the tender to step in when placing new packets. Accurate recording proved that this accomplished the best results, although it was hard to convince the masons until the actual figures stopped all argument.

In the arrangement of mortar boxes and packets, care was taken that bricklayers did not have to pick brick or mortar cross-handed. Even changing the order of box and packet for left-handed masons was found to pay.

Trials were made with the mortar boxes at different heights, first close to the floor and afterward raised above the staging. The output was increased materially by elevating the mortar, so horses 12 ins. high were built, and planks laid on these to form a bench. The cost of these benches was so slight, and the output so much increased, that it was proven of value to build them even on a pole scaffold. Study of performances also proved that mortar tubs and packets were to the best advantage [illegible] ins. from the wall.

MEASURING OUTPUT OF BRICKLAYERS.—The usual custom for gaging the individual output on a wall is by measurement. Thus each man works between two marks, and there is a tendency among the bricklayers to let each man take care of his allotted portion. To do away with this condition was necessary in following the plan laid out on this contract.

The question of measuring the output of each bricklayer was solved in the simplest way. Each bricklayer was told to pile his empty packets in his individual pile and these were counted each hour by wheeling them past the recorder.

There is a labor rule which forbids the line being slacked out and raised a course until each man has completed his portion. This is consistent with good workmanship. Its result is that the masons finishing first, under ordinary conditions, slow up their work until the delayed men have completed their sections. Counting the packets of the individual workmen changed this. It was found that the bricklayer who finished his section was glad enough to empty his packets by laying brick on the section of the man next who was waiting for stock or was behind for any reason. Instead of slowing his pace and killing time until the other man was caught up, he stepped over a few feet and kept busy.

WHEELBARROWS.—The time and cost studies on this job proved in repeated instances the previously discovered truth* that the losses due to workmen using traditional tools instead of tools best adapted to their work are much greater than the losses from their actual tendency to soldier or loaf. This was found particularly so in the case of the wheelbarrow.

Recording the number of brick each tender handled caused so much rivalry between different foremen, and in fact between the tenders themselves, that the wheelbarrow came in for its share of change and improvement. The average wheelbarrow holds from 50 to 60 brick, loose. The flat wooden wheelbarrow holds four packets, or 72 bricks. The "trucket," Fig. 2, a cross between a wheelbarrow and a baggage truck, was finally adopted. This trucket held 12 packets, or 216 brick. Owing to the fact that the two wheels were well back under the body, the trucket was handled easier than the old-fashioned wheelbarrow. The limit, however, is reached in 216 brick in most cases, as over 1,000 lbs. is concentrated on two wheels.

SECURING COMPETITION FOR HIGH RECORDS.—To engage the interest of the workmen in the endeavor to increase the output, charts showing the daily performance graphically were posted on the wall in the field office, where they could be seen by everyone on the job. In addition the bricklayer foreman on the building having the highest score one day was permitted to fly the largest flag the next day. Different size flags were provided, from 5 ft. by 8 ft. to 5 ins. by 8 ins. There were from four to six buildings under construction simultaneously, and a great deal of rivalry developed among the foremen in the attempt to get the largest flag. Miniature flags corresponding to those on the buildings were put on the charts posted in the field office to mark the race.

The enthusiasm which this system aroused is expressed in the fact that the most pessimistic foremen, who openly opposed the system at the start, were the strongest adherents and firmest believers at the finish.

OFFICE RECORDS OF PERFORMANCE AND COST.—Reports of the day's work were mailed to the main office daily. Here charts were made up showing the fluctuations of production and labor cost of the several gangs. Specimens of these charts are reproduced herewith in Fig. 4 (A, B, C and D).

Chart "A" shows the average hourly output per man from day to day on four different buildings. This is interesting, inasmuch as it shows how each gang stood in relation with the others, though it is not sufficient to tell the average effi-

*With Frank B. Gilbreth, Inc., 60 Broadway, New York City.

*See the paper "Shop Management," by Mr. F. W. Taylor, Trans. American Society of Mechanical Engineers, Vol. 24 (1903), p. 1337.

ciency of the foremen. Another chart made from the same data averaged the curves of "A" progressively, giving the gross average hourly output from the beginning of the job to any date, as is done for costs in chart "B."

In order to judge these records a knowledge of the conditions that existed upon the several buildings is necessary. For instance, the Office building (Parsons, foreman) had the thinnest walls, with fancy cutting for arch work, in view of which an average of nearly a hundred brick per man per hour is very satisfactory. The Stable (also Parsons), had a great many openings, plumb corners, and arches, and therefore could not be expected to compete with the Mill or Receiving buildings in number of brick laid. Knowing this, the fact that Parsons is low man in production is not exciting, for in looking at chart "C" it is found that his cost per thousand brick laid is low, for that class of work.

The true expression of the abilities of the different foremen is found in charts such as C and D. These endeavor to show the ratio of cost of each class of labor to the total labor cost, 100% representing the sum of foreman's, bricklayers' and tenders' payroll for the day.

Naturally, all that the bricklayers' line can be moved up or the tenders' line down is good. Look at chart C. Here is shown the reason why highest production does not get lowest cost in all cases. Note that the average percentage for bricklayers shown on the margin, left side, is 58%, while the average for tenders is 35%. In chart D, on the other hand, the bricklayers' average is 67%, the tenders' average showing 27%.

As tenders are not producers of scores by themselves, merely being the necessary evil enabling the bricklayers to run up the records, their percentage should be as low as possible. The saying on the wall for years has been, "a tender to every bricklayer," but performances on this work bring out the fact that the best work, as well as the cheapest, can be done when the tenders are from one-third to one-half the number of the masons.

On two of the other buildings of this group, for instance, the bricklayers' average was 72% and 68% respectively, and the tenders' average was 21% and 33%. These results were accomplished by the foreman shifting his men to suit conditions on the wall. Had there been no charts showing output, number of men, percentage of one group of men to the whole, etc., these results would not have been made. They show the ability of the foreman to place his men to advantage. Thus, chart D shows that Norton watched his tenders pretty closely, keeping their percentage down as much as possible. Under the conditions, Norton's record is good, for his building, the Mill, was straightwalled. There was never a minute when the tenders on this building did not have all they could attend to.

Field charts were made to cover this point especially, to show the various foremen why their records were what they were and point out the

FIG. 2. LOADED PACKETS ON TWO-WHEEL BARROW; LOAD ABOUT 1,000 LBS.

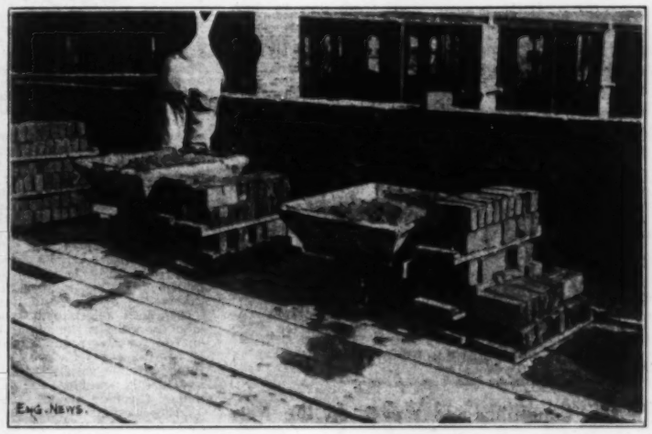
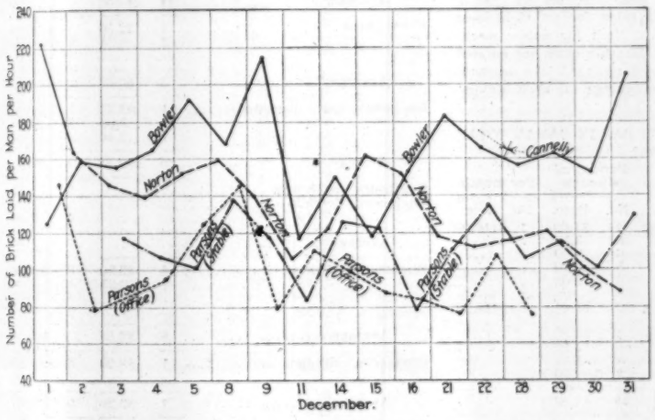
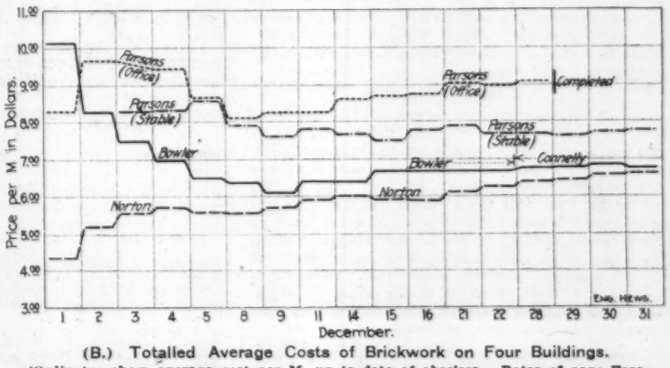


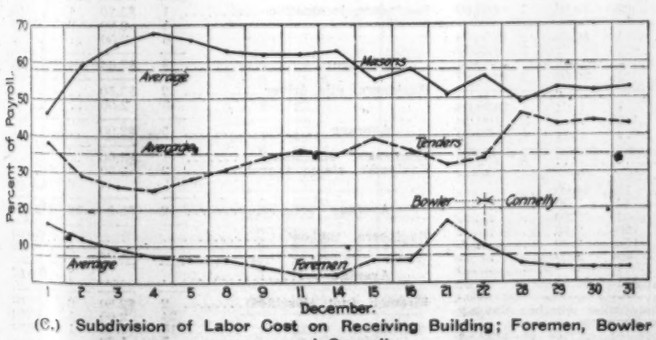
FIG. 3. VIEW ON STAGING, SHOWING PACKETS OF BRICK AND MORTAR-TUBS IN PLACE FOR BRICKLAYERS.



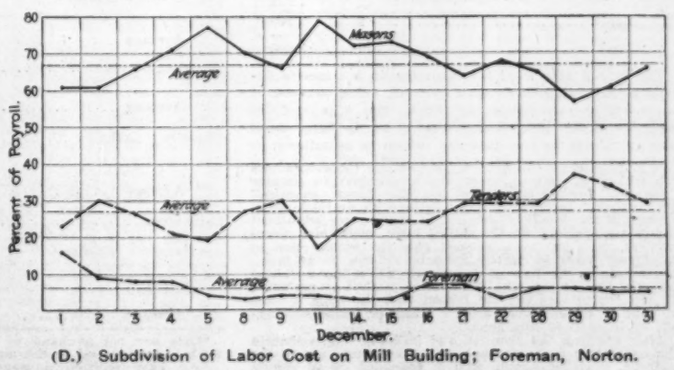
(A.) Average Hourly Output per Bricklayer During December, 1908.



(B.) Totalled Average Costs of Brickwork on Four Buildings.
(Ordinates show average cost per M. up to date of abscissa. Rates of pay: Foreman, $5 per day; Masons, 60 cts. per hr.; Tenders, 30 cts. per hr.; for 8-hr. day.)



(C.) Subdivision of Labor Cost on Receiving Building; Foremen, Bowler and Connelly.



(D.) Subdivision of Labor Cost on Mill Building; Foreman, Norton.

FIG. 4. SPECIMENS OF PERFORMANCE AND COST CHARTS FOR BRICKWORK OF ATWOOD & McMANUS BUILDINGS.

particular features which it was desirable to repeat or to eliminate.

In considering what was achieved on this contract, allowance should be made for the fact that the brickwork was started in midwinter and was rushed to completion in the fewest possible days regardless of weather conditions. While the output varied a great deal from day to day, it was far above ordinary results, especially under the difficult conditions of working, the interruptions and delays due to storms and low temperature of a New England winter, slow deliveries of lumber from Georgia to Boston, and the fact that the brickwork was strictly high-grade with walls jointed both sides.

The records on these six buildings erected under these conditions in four months, justify the expense of recording individual productions and maintaining a cost analysis department to chart the records and analyze the figures. Creating a spirit of emulation among the workmen down to the lowest grades, and posting the scores of performances, is apt to be little appreciated by one who has not studied the influence of these factors upon production.

Housing Conditions and Wages on the New York State Barge Canal and on the Ashokan Dam, Board of Water Supply, New York City.*

In September and October of 1908 a special investigation was made by the Bureau of Factory Inspection as to the observance of the provisions of the Labor Law concerning public work by the contractors for the Barge Canal. This investigation was undertaken as the result of numerous complaints of non-observance of the law, which had been received by the Department, and of special orders which had, in consequence, been issued by the Commissioner of Labor to all contractors. An inspector was engaged in this investigation continuously from Sept. 17 to Oct. 25, save for one or two short interruptions, and in the course of his work secured data, not only as to the observance of the law, but as to wage rates, number of aliens employed, and housing conditions where labor camps were maintained. Similar information secured in a similar connection (in this instance both complaint and request from the contractors furnished the occasion) was secured by the same inspector on Dec. 21 to 24, inclusive, concerning the work on the Ashokan Dam for the City of New York. This information concerning employment of aliens, housing conditions and wages on these two great public undertakings is deemed of sufficient value to be here recorded for general public information.

The Barge Canal.

Work on 26 different contracts was visited. On five of these only preliminary work was under way, or the work was nearly completed, and detailed reports therefor were not made. On the other 21 contracts a total of 4,516 workmen were employed. Of these 2,067, or 46%, were foreign born, only two of whom had taken out first papers for citizenship. Aliens were found at work on all but three contracts. Of the 18 contracts where aliens were found, on all but two labor camps were maintained in which a part or all of the aliens lived. Following is a summary of the reports of the inspector as to the character of the housing and sanitary conditions of these camps:

Condition Reported as—	Number of contracts.	Number of aliens employed.
"Poor"	1	132
"Fair"	4	274
"Good"	10	1,537
"Excellent"	1	100
Total	16	2,043

The formal reports of the inspector do not specify details as to conditions on each contract, being confined to a general characterization as above. But a general description of the labor camps as found on the barge canal was submitted by the inspector, which is as follows:

It is apparently the general rule among the contractors (to which, of course, there are exceptions) to provide "shanties" for the laborers at the job. These "shanties" or "shacks," together in some cases with outlying huts, constitute the laborers' camp. In some cases additional camps are provided for the skilled labor, mechanics, timekeepers, etc., but as a general rule the better class of employees board in nearby cities or villages or at farmhouses along the line of the canal, while the unskilled laborers live at the job. The latter method is preferred by the contractors for the reason that the help is close at hand to resume work after a storm or temporary layoff, or in case of emergency.

After erecting the shanties and building bunks therein the contractor turns the use of the building over to the padrone, or labor agent, who is depended on to supply all necessary unskilled laborers in return for the privilege of conducting the supply store for the men. The padrone also has for himself all moneys received for bunk space in the shanties. The charge for sleeping space averages about $1 per month per man.

As to the manner of boarding, the Austrians and Hungarians generally engage a "board boss" who buys and cooks the food. Occasionally a married couple does this. At the end of the month the cost is assigned pro rata among the members of the mess. The Italian, however, prefers to buy his own supplies and do his own cooking. The contractor protects the padrone by deducting from the wages of the men the amount owing to him. We are thus enabled to learn about how much the bills for supplies will average, and find it to be from $12 to $15 per month, including bunk space at the shanty. These bunks are merely board berths filled with straw or hay, over which the occupant throws an old blanket of some kind. It is exceptional to find cots or beds. Usually the bunks are all together in a large room which is badly ventilated, these men seemingly having a dread of fresh air for sleeping purposes, although they work in it all day. Sometimes the hay or straw is changed, at least I am so informed; but, as a matter of fact, I saw no indications that such is the case. The camps, with few exceptions, are located near running streams or lakes, but, truth to tell, the alien laborer generally remains among the great unwashed.

In several instances the padrones have taken out licenses to sell beer. In some cases whiskey is sold without a license. Arrests have been made for this violation but, so far as learned, no convictions have been obtained. The contractors, for obvious reasons, discourage the selling of beer and liquors at or near the camps.

Instances are known where the padrones charge the men for getting the jobs, charge them for sleeping room, charge for the room whether used or not (as the price of retaining a job), which is extortion pure and simple; this, together with what is derived from the sale of food and drink, enables the padrone to get about all the money the men spend. Cases are known of one padrone bidding against another by offering to supply all necessary unskilled labor at a lower rate of wages in return for the "privilege" of the shanty and store; as a matter of fact the laborer is and has been for years at the mercy of these padrones who, next to the men's own unclean habits, are the curse of their existence. Still it has to be acknowledged that but little sickness exists among these men, and they are often able to take a vacation in their foreign homes during the winter months.

In some instances medical attendance is called in only when necessary; in other instances a small weekly or monthly sum for medical service is deducted from the pay, and regular visits to the men are made by the company physician and when sickness occurs no extra charge is made. The camps, as a whole, are carefully located on high ground and allow for ample drainage, although improvement could be made at some camps. The drinking water is usually supplied from driven wells of ample depth to insure a good quality of water. On all contracts water-boys are employed whose duty it is to keep the men well supplied with fresh drinking water.

Transcripts were made from payrolls of rates of wages paid by the barge canal contractors for a total of 4,352 employees. Wages are commonly paid by the hour, day or month, weekly rates appearing in case of only seven employees. In the following summary, for all hourly (and weekly) rates, equivalent rates for an eight-hour day (eight hours being the legal limit for public work) have been computed and used. Monthly rates are entered separately.* The actual rates are arranged in a descending scale to which is added the average for each occupation.

RATES OF WAGES ON STATE BARGE CANAL WORK IN 1908.†

Occupation.	Per day of 8 hours. No.	Per day of 8 hours. Rate.	Per month. No.	Per month. Rate.
Blacksmiths ..... Max.	1	$4.00	1	$110.00
	8	3.50	..	.....
	6	3.00	..	.....
	5	2.80	..	.....
	3	2.00	..	.....
Average	32	$3.04	1	$110.00
Blacksmiths' helpers	1	$3.20	..	.....
	10	2.00	..	.....
	8	1.75	..	.....
	1	1.20	..	.....
Average	30	$1.82	..	.....
Blasters. (See also Potter men.) Boilermakers	..	.....	1	$95.00
Brakemen	6	$2.50	1	$65.00
	9	2.00	..	.....
	5	1.50	..	.....
Average	28	$1.91	1	$65.00
Captains, dredge	1	$5.00	2	$150.00
	..	.....	1	125.00
Average	1	$5.00	3	$141.67
Captains, tugboat	..	.....	1	$120.00
	..	.....	3	100.00
	..	.....	4	80.00
Average	..	.....	8	$92.50
Carpenters	10	$4.00	..	.....
	49	3.00	..	.....
	43	2.80	..	.....
	29	2.50	..	.....
	158	2.40	..	.....
	40	2.00	..	.....
Average	351	$2.58	..	.....
Carpenters' helpers	34	$2.00	..	.....
	10	1.75	..	.....
	11	1.60	..	.....
	4	1.42	..	.....
Average	64	$1.84	..	.....
Channel men	1	$4.00	..	.....
	5	3.50	..	.....
Average	6	$3.58	..	.....
Channel men's helpers	3	$2.00	..	.....
	3	1.50	..	.....
Average	6	$1.75	..	.....
Coal passers	2	$1.50	..	.....
Concrete finishers	3	$3.20	..	.....
	8	2.40	..	.....
	1	1.75	..	.....
Average	13	$2.57	..	.....
Concrete finishers' helpers	1	$2.40	..	.....
	2	1.60	..	.....
	1	1.50	..	.....
Average	4	$1.78	..	.....
Cranemen, dredge & steam shovel	..	.....	1	*$122.50
	..	.....	9	90.00
	..	.....	2	80.00
Average	..	.....	15	$94.30
Deckhands, dredge	30	$2.00	2	$55.00
	..	.....	13	50.00
Average	30	$2.00	15	$[illegible]
Deckhands, tugboat	3	$2.00	6	$50.00
Derrick swingers. (See also engineers, firemen & foremen.)	..	.....	4	$90.00
Dredge operators. (See also captains, cranemen, deckhands, engineers, firemen, foremen, pitmen and scowmen.)	..	.....	9	$125.00
	..	.....	2	70.00
Average	..	.....	15	$113.67
Drill runners	17	$2.50	..	.....
	14	2.00	..	.....
	3	1.75	..	.....
Average	46	$2.26	..	.....
Drill runners' helpers	6	$1.75	..	.....
	18	1.60	..	.....
	14	1.36	..	.....
Average	44	$1.53	..	.....
Electricians	1	$2.50	1	$110.00
	2	2.24	1	100.00
	[illegible]	.....	1	90.00
Average	3	$2.33	3	$100.00
Engineers (not classified)	1	$3.33	1	$150.00
	12	3.00	3	90.00
	1	2.40	..	.....
Average	25	$2.88	24	$82.71
Engineers, cableway	..	.....	2	$100.00
Engineers, derrick	..	.....	1	$80.00
	..	.....	4	75.00
Average	..	.....	7	$76.00
Engineers, dinkey	4	$2.50	2	$80.00
	4	2.25	4	75.00
	..	.....	8	70.00
	..	.....	9	65.00
Average	8	$2.38	23	$69.78
Engineers, dredge	1	$3.20	6	$100.00
	..	.....	3	90.00
Average	1	$3.20	9	$96.67
Engineers, excavator	5	$1.50	..	.....
Engineers, hoisting	..	.....	1	$100.00
	40	3.00	5	80.00
	2	2.40	..	.....
Average	57	$2.98	6	$83.33
Engineers, locomotive	1	$3.20	1	$90.00
	1	2.80	3	65.00
	6	2.50	..	.....
Average	8	$2.63	4	$71.25
Engineers, pile driver	2	$3.50	..	.....
	3	2.50	..	.....
Average	5	$2.90	..	.....
Engineers, stationary	1	$3.00	..	.....
Engineers, steam shovel	2	3.50	1	$175.00
	..	.....	6	125.00
Average	2	$3.50	12	$141.46
Engineers, tugboat	..	.....	1	$110.00
	..	.....	3	80.00
Average	..	.....	7	$88.57
Firemen (not classified)	2	$2.80	6	$75.00
	24	2.00	1	55.00
	15	1.75	1	40.00
	5	1.60	..	.....
Average	65	$2.03	17	$66.32

*From Bulletin N. Y. State Dept. of Labor, March, 1909; John Williams, Commissioner, Albany, N. Y.

*Data are not at hand to determine whether Sunday work is represented in the monthly rates or not.

†We have omitted a number of entries of only a relatively few men at a given rate of wages; therefore in many cases the totals in each class appear to be excessive. The highest and lowest rate is given in each case.—Ed.

*Includes board reckoned at $22.50 per month.

Occupation.	Per day of 8 hours. No.	Rate.	Per month. No.	Rate.
Firemen, cableway	2	$2.00	..	.....
Firemen, derrick	1	$2.50	..	.....
	4	1.75	..	.....
Average	5	$1.90	..	.....
Firemen, dredge	1	$2.00	9	$70.00
	2	1.75	1	66.00
	..	....	3	50.00
Average	3	$1.83	13	$65.08
Firemen, locomotive	..	....	1	$55.00
Firemen, stationary	..	....	6	$60.00
Firemen, steam shovel	..	....	2	$65.00
Average	..	....	5	$58.00
Firemen, tugboat	..	....	3	$60.00
	..	....	3	50.00
Average	..	....	7	$55.00
Firemen's helpers	2	$1.60	..	.....
Foremen (not classified)	1	$4.50	3	$150.00
	11	2.80	4	80.00
	13	2.50	..	.....
	1	1.75	..	.....
Average	44	$2.83	16	$110.69
Foremen, derrick	2	$1.75	1	$90.00
	..	....	1	60.00
Average	..	....	2	$75.00
Foremen, dump	1	$2.00	..	.....
Foremen, dredge	6	$2.80	1	$125.00
	..	....	1	60.00
Average	6	$2.80	3	$86.67
Foremen, mason	2	$6.00	1	$150.00
Foremen, of laborers	..	....	1	$100.00
	..	....	1	90.00
Average	..	....	2	$95.00
Foremen, track	1	$2.00	..	.....
Foremen, rigger	..	....	1	$125.00
Helper, general	..	....	1	$75.00
Iron workers	..	....	1	$100.00
	..	....	1	70.00
Average	..	....	2	$85.00
Jackmen	4	$1.60	..	.....
Laborers (foreign)	1	$3.00	..	.....
	65	1.75	..	.....
	325	1.50	..	.....
	167	1.44	..	.....
	687	1.40	..	.....
	104	1.35	..	.....
	200	1.36	..	.....
	274	1.20	..	.....
Average	1,963	$1.42	..	.....
Laborers (native)	125	$2.00	..	.....
	72	1.75	..	.....
	58	1.60	..	.....
	45	1.50	..	.....
	93	1.44	..	.....
	40	1.40	..	.....
Average	452	$1.69	..	.....
Laborers (citizenship not reported)	30	$1.75	..	.....
	125	1.50	..	.....
	220	1.40	..	.....
	24	1.20	..	.....
Average	409	$1.45	..	.....
Machinists	1	$4.00	1	$135.00
	9	2.40	..	.....
	6	2.00	..	.....
Average	28	$2.53	4	$108.75
Machinists' helpers	3	$2.80	4	$60.00
	3	1.75	..	.....
Average	11	$2.29	4	$60.00
Oilers	2	$1.75	..	.....
Oilers, dredge	..	....	2	$80.00
	..	....	6	70.00
	..	....	3	60.00
Average	..	....	11	$69.09
Oilers, tugboat	..	....	8	$60.00
Pile drivers	4	$2.40	..	.....
	2	1.75	..	.....
Average	8	$2.14	..	.....
Pipe fitters	1	$2.40	..	.....
Pitmen, dredge	6	$1.75	..	.....
Potter men (blasters)	1	$2.75	..	.....
	1	2.25	..	.....
Average	2	$2.50	..	.....
Potter men's helpers	2	$1.75	..	.....
Pumpmen	3	$2.50	1	$80.00
	10	2.00	2	50.00
	3	1.50	..	.....
Average	28	$1.93	9	$60.00
Repairmen	1	$2.75	1	$85.00
	7	2.00	..	.....
	2	1.60	..	.....
Average	11	$2.03	1	$85.00
Riggers	2	$4.00	2	$90.00
	17	2.00	..	.....
	1	1.75	..	.....
Average	37	$2.41	2	$90.00
Riggers' helpers	1	$2.50	..	.....
	13	1.60	..	.....
	1	1.50	..	.....
Average	31	$1.76	..	.....
Rock shovel operators	..	....	2	$150.00
Scowmen, dredge	..	....	2	$55.00
Signalmen	3	$2.00	..	.....
	1	1.50	..	.....
Average	4	$1.88	..	.....
Stone cutters	4	$4.00	..	.....
Stone masons	7	$4.00	..	.....
Superintendent, cableway	..	....	1	$110.00
Supply house men	1	$2.00	..	.....
	1	1.50	..	.....
Average	2	$1.75	..	.....
Teamsters	2	$2.00	1	$60.00
	6	1.83	8	50.00
	15	1.75	..	.....
	3	1.50	..	.....
Average	26	$1.76	9	$51.11
Teamsters (including teams)	36	$4.00	..	.....
	10	3.20	..	.....
Average	48	$3.81	..	.....
Track cleaner	1	$1.40	..	.....
Trackmen	1	$2.00	..	.....
Watchmen (average)	21	$1.91	28	$56.14
Waterboys (average)	16	$0.91	..	.....
Winchmen (average)	3	$1.58	..	.....

Ashokan Dam.

At the time of the investigation of conditions at the Ashokan Dam (December, 1908) only a little over 800 men were employed, but it is anticipated that during the coming season there will be 3,000 men at work.

The nativity of the 824 employees at the time of inspection was as follows:

American (white)	162	German	5
American (negro)	123	Hungarian	4
Italian	424	Slavic	3
Austrian	33	Danish	2
Russian	20	British	1
Polish	12	Canadian	1
Swedish	10	Roumanian	1
Irish	9	Greek	1
Lithuanian	8		
Finnish	5	Total	824

Of the foreign-born, 11 (4 Italian, 3 Irish, 1 German, 2 Danes, 1 Canadian) had become naturalized, and two others (Italian), had taken out first papers. The proportion of alien labor on the work was, therefore, 64%.

The situation of the work, in the southern portion of the Catskill Mountains, is such as to practically necessitate provision for residence of the bulk of the employees at the work, and of the 824 employees in December, 705 were quartered at the camp provided by the contractors, the remainder being located in nearby villages. The necessity for providing housing at the work is recognized in the specifications accompanying the contract and detailed regulations are laid down therein to insure proper sanitary conditions in the labor camp.* These regulations are as follows:

Sec. 17. * * * Hose connections and hose, water casks, or other sufficient means shall also be provided for fighting fires in the more important temporary structures, and responsible persons shall be instructed as to the operation of such fire apparatus, so as to prevent or minimize loss of time from fire. The water supply furnished by the contractor shall include a sufficient supply of drinking water of good quality to be furnished to all his employees. He shall furnish sufficient water, and ample bathing and clothes washing facilities for his employees.

Sec. 21. The contractor shall provide suitable and satisfactory buildings for the housing, feeding and sanitary necessities of the men and suitable stabling for the animals employed upon the work.

Sec. 22. The contractor shall retain the services of one or more qualified medical and surgical practitioners, who shall have the care of his employees, shall inspect their dwellings, the stables and the sanitaries at least once a week, or oftener if the health conditions of any portion of the camp shall make more frequent inspection desirable, and shall supply medical attendance and medicines to the employees whenever needed. The contractor shall provide one or more buildings, properly fitted for the purposes of a hospital, with facilities for heating and ventilating in cold weather and for screening and ventilating in warm weather. These hospitals shall have an ample number of beds to properly care for sick or injured employees, and shall be provided with all articles necessary for giving "first aid to the injured," as well as with all necessary medicines and medical appliances for the proper care of the sick and injured. Another suitable building shall be provided and equipped as a contagious hospital, and any employee, who shall be found to have a contagious or infectious disease, shall be at once removed from the camp to this hospital, and there properly isolated and treated. The contractor shall give the engineer satisfactory assurance that the above medical and hospital arrangements have been made.

Sec. 23. Sanitary conveniences for the use of all persons employed on the work shall be constructed and maintained by the contractor in sufficient number, in such manner and at such places as shall be approved. All persons connected with the works shall be obliged to use these conveniences. The sanitaries shall be connected with one or more disposal plants, where all sewage shall be treated, so as to yield a reasonably clear and colorless effluent, free from disagreeable odor. Samples of the effluent shall show no increase in the oxygen consumed after being kept three days at a temperature of eighty degrees Fahrenheit. In addition to the above, pan-closets shall be provided and properly cared for at convenient points on the parts of the work remote from the disposal plants, whenever necessary for the prevention of nuisances. The contractor shall rigorously prohibit the committing of nuisances within the limits of the work.

Sec. 24. Garbage, both liquid and soil, shall be promptly removed from the buildings and immediately placed in approved tight receptacles of sufficient capacity for about one day's ordinary production. At least once in twenty-four hours all such garbage shall be incinerated or otherwise thoroughly and satisfactorily disposed of so as not to create a nuisance.

Sec. 25. The sanitary precautions, including those to prevent contamination of the waters of Esopus Creek, and the care of the employees shall at all times be satisfactory to the engineer, to the department of health of the city of New York, and to the State Board of Health. The contractor shall promptly and fully comply with all orders and regulations in regard to these matters.

Sec. 26. For providing plant, tools and equipment and for furnishing, erecting, maintaining and removing the construction plant, camps, hospitals, temporary water supply, roads, trestles and other temporary works, the contractor shall receive no direct payment, except as otherwise expressly stipulated, but it is understood that compensation for them is included in the prices to be paid for the various items of the contract.

Sec. 27. The contractor shall not sell and shall neither permit nor suffer the introduction or use of intoxicating liquors upon or about the works embraced in this contract or upon any of the grounds occupied or controlled by him.

Sec. 29. * * * The buildings and the shanties for the housing of the workmen shall be, so far as practicable, located downstream from the works, and the contractor will be required to avoid permanently disfiguring the landscape, in the erection of any of these buildings or of those for other construction purposes.

Following is the description by the Department's inspector of conditions at the Ashokan labor camp as he found them last December:

In compliance with the terms of the contract MacArthur Bros. Co. and Winston & Co. have erected a model camp on Winchell Hill near the Olive Bridge Dam and about one-half mile from Brown's Station. The camp is situated in a grove of trees on an elevation of from 400 to 600 ft. above sea level. The site of the camp has a natural drainage to a bluff overlooking Esopus Creek below the dam; a sewage disposal plant has been built and sewers laid throughout the camp; water is provided for fire, sanitary and drinking purposes; the drinking water is filtered, streets have been cut through, are properly drained and electrically lighted; garbage and ashes are collected and disposed of daily; a school, hospital, bakery, store, bank, icehouse, etc., have been provided; barracks, dormitories, dining hall and cottages have been built, all in a substantial manner, the only difference between some of these temporary structures and permanent ones being the lack of brick chimneys, cellars, plastered inside walls and shingled or clapboarded outsides, although some have these latter finishings.

Following is a description of a typical four-room house for laborers with families, which will apply to nearly all four-room houses. Dimensions of main portion: 16 × 40 ft., with an ell 12 × 12 ft. It is built with frame work of ordinary 2 × 4 and 2 × 6-in. timber, rough boards on outside and sheathed with planed matched boards on the inside. The house is well ventilated and is covered, roof and sides, with rubberoid or amazon paper, making it warm and weatherproof; the floors are doubled with paper between. The cost of these houses, not including charges for sewer and water system, is $400. Such a house rents for $15 monthly, *including all fuel, water and sanitary protection*; the three-room houses, built just as good and with like conveniences and fuel supply, rent for $12 monthly. Ample garden space surrounds the houses and many families raise their own vegetables and chickens. The men work but eight hours per day and have ample time in which to attend to these matters. The arrangement of a four-room house is as follows: From the front porch a door leads to the main living room; to the left of this room is the family bedroom and to the right the bedrpom for boarders. The latter room is of ample size to accommodate four double beds and contains from four to six windows. Directly in the rear of the living room, in the ell, is the kitchen with an exit to a small rear porch and to the yard. Cleanliness of every portion of the building and surroundings is imposed upon the tenant by the contractor.

In the quarters for laborers without families the buildings are arranged as barracks and dormitories. The former are generally divided into rooms containing two double and one single bunk, provided with excelsior mattresses; the charge is $1.50 per month in four of the barracks, and $2 per month in the other four, there being eight in all. At these barracks the occupants furnish their own food and bed coverings, but are fur-

*In addition to regulating housing conditions the contract requires, in accordance with the labor law, an eight-hour day, payment of prevailing rate of wages and payment of wages in cash. It is also stipulated that any necessary expense incurred by a county, town or city in any criminal action or proceeding against any person employed on the work, or "in the suppression of riots among persons employed on said work" or in the prevention of crimes among them shall be a claim against the city of New York for any expense of the city for which the contractor shall be responsible. One of the specifications touches the safety of workmen by providing that if at any time any methods or appliances appear to the city's engineer to be unsafe, inefficient or inadequate for securing the safety of the workmen, the quality of work or the rate of progress required, he may order the contractor to increase their safety and efficiency, or to improve their character and the contractor shall comply with such orders, although the failure of the engineer to make such demand shall not relieve the contractor from his obligation to secure the safe conduct of work, and the contractor alone shall be responsible for the safety, efficiency and adequacy of his plant, appliances and methods.

nished with stoves and fuel by the contractor. At the dormitories, which are mostly occupied by skilled workers without families, double and single rooms are provided. These rooms contain beds instead of bunks, and the men take their meals at the dining hall, the charges for board being $20 per month for double rooms, and $22 per month for single rooms. Plenty of water for all purposes is provided at the barracks, and at the dormitories shower baths are installed.

There were in all 130 cottages at the camp with two others under construction. The following table shows the size of the cottages and the nationality of the occupants:

	Number of cottages with				
Occupied by	6 Rooms.	5 Rooms.	4 Rooms.	3 Rooms.	Total.
Americans (white).	1	1	17	16	35
Americans (negro).	..	..	4	17	21
Italians	1	4	64	1	70
Slavs and Poles	..	..	3	..	3
Austrians	..	..	1	..	1
Total	2	5	89	34	130

In the majority of the cottages boarders are taken. This is practically universal among the Italians, occurs frequently among the Negroes, but in only a few cases among the American tenants. Thus boarders were taken by all but two of the 70 Italian tenants, by seven out of 21 Negro tenants, but by only four of the 35 Americans. The four Austrian, Slavish and Polish tenants all took boarders.

Four of the eight barracks have four rooms and four have nine rooms. One four-room barrack was occupied by Negroes alone, but the other seven were occupied by different nationalities (including Negroes) in various combinations, but always, however, with separate rooms for each nationality.

Neither living at the camp nor trading at the store is compulsory; a considerable number of employees board at farm houses, boarding houses, summer hotels, etc., in the vicinity of the work. At a dozen boarding houses in the vicinity of Brown's Station which have boarded employees of the contractors the following rates were charged: At three $20 per month; at one, $7 per week; at two, $6 per week; at two, $5.50 and $6 per week; and at four $5 per week. Smaller camps are also maintained at South Wing, Lawson Hill and East Dike where sanitary precautions are rigidly maintained. No main sewers are provided, but cesspools that are cleaned at frequent intervals are used instead. When it is understood that all buildings at these camps must be destroyed or removed upon the completion of the contract, no surprise is felt that the contractor should prefer that as many men as possible find boarding houses off the job. It is expected that the coming summer will find some 3,000 men at work on this contract, which means a camp village of at least 4,000 persons, and facilities must be found or created for accommodating as many of them as desire to live at the camp.

Much has been said and written about the company store and the "brass check" system of wage payments. When a man goes to work on this contract he is assigned a number, he can obtain board at numerous places where he will be with people of his own nationality; or, he can live at one of the barracks and board himself; or, he can live at the company's boarding house where the price is the same to all. Should he want to purchase anything he can, if provided with funds, purchase at the company store or of Levi Elmendorf at the station or of Frank Vittervitz at Tongor, or of one of the many peddlers who have permits to trade at the camp. Should he wish to go further he can purchase at Shokan or Kingston. Should he be without funds or, having worked a day, desire a loan with which to purchase necessities, he can apply to the paymaster at the office and obtain a paper check which represents a loan, without interest, on his wages earned *but not yet due*, and is good for its face value at the company store; if any change is due, after the purchase, it is given in brass checks (of which there are five, numbered 1, 5, 10, 25 and 50, representing cents) which can again be used at store at their full face value. Money is not given in change unless money is paid for the article purchased; in other words, if cash is paid cash is given in change, if a paper order is given brass checks are given in change. The reason for this is obvious. Intoxicants must be kept from the men as much as possible and gambling is strictly prohibited. The men can buy everything necessary at the store, but they cannot buy liquor. They can exchange the brass checks for cash at the office on pay days, *but cannot turn in more than they have drawn out* nor can the checks be exchanged for cash by *non-employees*. They are worth 100 cts. on the dollar for everything needful but are of little or no value to outsiders. However, cases have been noted when some man had more than his share of checks which he was willing to sacrifice at less than face value and the purchaser (not always an employee) has traded them in at the store. The use of these orders and checks is in no way compulsory as the contractor pays weekly in cash and the best evidence that they are not used as a "system of wage payment" lies in the fact that during July, 1908, when the (so far) maximum force of 1,961 men was at work there was less than $1,000 worth of these checks in circulation, or about 50 cts. per man. However, the use of these checks even to the present moderate extent constitutes a technical violation of the cash payment of wages law as they are charged against the money earned and are thus a payment of wages and they are not cash under the terms of the Labor Law, although they are current cash at the camp. There is, therefore, no alternative to forbidding their use.

By the terms of the contract the contractor is under bonds to protect the community in which the work is located against paupers, etc. He cannot be expected to make an indefinite number of small loans without security (although he does so without interest) and the only security possible is that given by the wages earned. If loans are made in cash it immediately opens the way to "bootleggers," gambling, etc., in camp. On the other hand, if the contractor pays strictly in accordance with the terms of the law a new employee must wait for from one to two weeks without funds other than what he brings with him. And inasmuch as many of the new employees reach camp in the spring and summer with little or no money they are apt to become a menace to the community and the contractor becomes liable. It is entirely impracticable to install a system of credit at the store. No one can expect a business firm to give indiscriminate credit without security, and again comes the fact that the only security that can be given is the money to become due, and, under the law, charges for groceries, etc., are not a legitimate offset against wages earned (see Sec. 13 of Labor Law) and the security if given under these circumstances would prove legally valueless. The only other plan that appears in any degree feasible is for the contractor to advance daily in cash, for a period of one month, at least one-half the wages earned. This amount should be sufficient for even the lowest grade of unskilled laborer to maintain himself, and at the expiration of one month these advances could be cut off and the man paid weekly, for by that time, if he is sober and industrious, he will be able to get along without further loans. The bookkeeping made necessary by this plan should not exceed that which is already made necessary by the issuing of the paper checks.

At this point it might be proper to mention that there are no padrones connected with the contract and all money earned is preserved to the employee, excepting, of course, that which he naturally cares to spend. Some men were obtained from employment agencies in New York City during the past summer, including the information bureau of the United States Immigration Service, but the larger number of men came directly to the job of their own volition.

In accordance with the contract, and with the desire of the contractors, sanitary conditions are maintained. At many conspicuous points, in and about the camp, the following notice is posted in English and Italian and is also made part of the permits issued to peddlers:

> Pursuant to the statute in such case made and provided, and in compliance with the conditions of the contract between us and the City of New York, public notice is hereby given that no wagon or pack peddler, no canvassers, solicitors, or agents, no delivery or peddling wagon will be permitted to enter upon any property occupied or controlled by us or under our control pursuant to the provisions of our contract with the City of New York for the construction of the Main Dams for the Ashokan Reservoir without special permit in writing, duly issued by us. Reliable and responsible tradesmen will be furnished with the necessary permit on their application in writing and upon their agreeing to comply with the following conditions:
>
> (1) No peddler, agent, person or corporation shall sell, give away or carry any intoxicating liquors of any character upon or about the ground or works embraced in our contract, or in or upon any of the ground occupied or controlled by us.
>
> (2) No peddler, agent, person or corporation shall carry or offer for sale any vegetables, meats, fish, milk, provisions, food or drink which are not in all respects strictly fresh, and properly iced and carried in covered conveyances so protected that no substance conveyed thereby shall be exposed to sun, dust or flies.
>
> (3) No peddler, agent, person or corporation shall buy or attempt to buy, trade, bargain, barter or exchange in or for any brass, copper or other metals, rope, rubber, leather, wood, coal or lumber, or any material commonly called junk, nor shall he, they or it pick up or take away any of the above named materials.
>
> These conditions are in accordance with the provisions of our contract with the City of New York, and are made necessary to safeguard the health of our employees, and to comply with the strict sanitary restrictions under which we are bound by our contract with the City. The restrictions as to trade and barter in junk are made necessary because of the enormous losses of fittings for pipes, brasses for engines and of brass and other castings, small tools and miscellaneous supplies.
>
> The public will appreciate the fact that the area covered by our contract makes it impossible for us to have sufficient watchmen to guard against these losses.
>
> If any person to whom a permit has been issued shall violate any of these restrictions or conditions the permit will be summarily revoked.
>
> Mac Arthur Brothers Co. and Winston & Co.
> Dated July 10, 1908.

To this notice is appended a list of 13 persons from Brown Station, Kingston, Shokan, Tongor and West Shokan to whom permits have been issued to peddle at the camp groceries, baked goods, meats, fruits and vegetables, dairy products, clothing, etc.

A comparison of prices at the store should satisfy anyone that they are neither exorbitant nor unreasonable. A few articles are herewith mentioned as illustrative of all.

	Cost.		Selling price.	
Article.	Price.	Unit.	Price.	Unit.
Hosiery	$0.75	doz.	$0.10	pair
	1.25	"	.15	"
	2.00	"	.25	"
Gloves	4.50	"	.50	"
	9.00	"	1.00	"
	13.50	"	1.50	"
Underwear	4.50	"	.50	garment
	9.00	"	1.00	"
	12.00	"	1.50	"
Shoes	1.85	pair	2.50	pair
	2.00	"	2.75	"
	3.00	"	4.00	"
	3.50	"	5.00	"
Overalls	8.50	doz.	1.00	piece
	9.00	"	.50	"
Work shirts	4.50	"	.50	"
	9.00	"	1.00	"
Rubber boots	4.50	pair	5.50	pair
Coffee	.13	lb.	.20	lb.
	.18	"	.25	"
	.27	"	.35	"
Tea	.25	"	.40	"
	.35	"	.50	"
	.50	"	.75	"
Butter	.34	"	.38	"
Eggs	.32	doz.	.38	doz.
Bacon	.14	lb.	.18	lb.
Hams	.14	"	*.20	"
California ham	.08	"	.10	"
Tomatoes	1.00	doz.	.12	can
Corn	.85	"	.10	"
Baked beans	.90	"	.10	"
Potatoes	.90	bu.	1.25	bu.
Beans	2.45	"	.06	lb.
Porterhouse steak	....	....	.22	"
Rib roast beef	....	....	.18	"

*Sliced; whole 16 cts.

The above prices do not include freight, cartage or any expense of storage or handling in the store. Freight rates to the camp exceed rates to Kingston by 12, 11, 9 and 7 cts. per 100 lbs. on first, second, third and fourth class rates respectively.

Three schools are maintained at the camp. One is an evening school which was opened in November in accordance with the following notice, which, in English, Russian, Polish, Slovak and Hungarian, was posted about the camp:

> "Notice:
>
> The Evening School for Laborers Will Be Opened Monday, November 4, 1908, at 7.00 o'clock
>
> All Those Who Wish to Learn the English guage May Take Part in the Lessons."

Although the Italians have formed a majority of the attendants at this school, all of the other nationalities have been represented. The enrollment from November 4 to Dec. 22 was between 60 and 70 with an average attendance of 34.

When the contract for the main dams of the Ashokan Reservoir was let, there was one school in the district of about 20 pupils, situated near Brown's Station, but the increased population caused by the work made that school in an overcrowded condition during the spring term of 1908. This condition was adjusted in the fall, when Mr. J. O. Winston had built and equipped a school house at the camp and a second teacher secured for the district. During the fall term the number of pupils continued to increase so that a third teacher was employed. The three teachers now have under their charge 95 pupils ranging from 6 to 15 years of age, of whom 45 are of American (white) 34 of Italian, 11 of Negro, 3 of Austrian and 2 of German parentage.

In the same building with the "Camp School" there is maintained by the Society for Italian Immigrants a kindergarten, which now has 30 children on its roll from 3½ to 5½ years of age.

Plans are now being prepared by the contractor to double the size of the school building, and in the spring a day school will also be held for the night shift.

A transcript from a December payroll shows the wages paid on the Ashokan Dam work in a great variety of occupations. In the majority of cases wages are paid by the hour, in some by the week and in only a few instances by the day. In the following summary the rates per week* and per day are as recorded in the payroll, but for the hourly rates equivalent rates for an eight-hour day have been used. For those occupations in which more than six employees are represented, average rates have been computed.

RATES OF WAGES ON ASHOKAN DAM WORK IN 1908.

Occupation.	Per day. No.	Per day. Rate.	Per week. No.	Per week. Rate.
Axeman	1	$2.00	..	....
Bakers	..	....	1	$19.19
	..	....	1	13.55
	..	....	3	11.54
Blacksmiths	1	4.00	..	....
	1	3.20	..	....
	4	2.80	..	....
	1	2.60	..	....
	2	2.40	..	....
Average	9	2.87	..	....
Blacksmiths' helpers	2	1.60	..	....
	1	1.40	..	....
Boarding-house manager	..	....	1	20.79
Bookkeeper	..	....	1	40.38
Boys	1	1.00	..	....
Boys, cableway bell	1	1.60	..	....
	2	1.40	..	....
	1	1.32	..	....
Boys, toolhouse	1	1.20	..	....
Boys, water	5	1.00	..	....
	5	.80	..	....
Average	10	.90	..	....
Brakemen	3	1.60	1	12.41
	2	1.40	..	....
Butcher	..	....	1	13.55
Cableway hooker	1	2.00	..	....
Carpenters	2	4.00	..	....
	1	3.20	..	....
	11	2.80	..	....
	2	2.40	..	....
	1	2.20	..	....
	8	2.00	..	....
Average	25	2.60	..	....
Carpenters' helpers	1	1.80	..	....
	1	1.32	..	....
Cashier (store)	..	....	1	15.00
Channeler	1	3.20	..	....
Channelers' helpers	3	2.00	..	....
Civil engineer	..	....	1	48.46
	..	....	1	46.15
	..	....	1	22.58
	..	....	1	20.79
	..	....	1	17.31
	..	....	1	11.29
Clerks	..	....	1	13.55
	..	....	1	10.38
Clerks, cement	..	....	1	15.80
	..	....	1	10.61
	..	....	1	10.16
Clerks, credit	..	....	1	18.46
Clerks, freight	..	....	1	17.31
Clerks, receiving	..	....	1	15.80
Clerks, store	..	....	1	15.00
	..	....	2	13.55
	..	....	5	11.29
Clerks, toolhouse	..	....	1	13.55
Average—Clerks	..	....	17	13.19
Coachman	1	1.50	..	....
Commissary manager	..	....	1	39.52
Cook	..	....	1	13.85
Cranesman, steam shovel	..	....	1	16.16
	..	....	2	15.80
Crusher feeder	1	2.00	..	....
	1	1.60	..	....
Dish washer	..	....	1	11.54
Draftsman	..	....	1	11.29
Drill runners	7	3.00	..	....
	8	2.00	..	....
	1	1.80	..	....
Average	16	2.43	..	....

*Data for determination of whether weekly rates represent six or seven days of work are not at hand.

Occupation.	Per day. No.	Per day. Rate.	Per week. No.	Per week. Rate.
Electrician	1	2.40	..	....
Electrician, assistant	1	1.60	..	....
Engineers, cableway	3	2.80	..	....
Engineers, compressor	..	....	1	28.22
	..	....	1	16.93
	..	....	1	14.68
	..	....	1	14.00
Engineers, crusher	1	2.00	..	....
Engineers, excavator	1	3.20	..	....
	4	2.80	..	....
Engineers, hoisting	1	2.80	..	....
	11	2.20	..	....
	3	2.00	..	....
Engineers, locomotive	..	....	1	19.19
	..	....	1	17.31
	..	....	2	16.93
Engineers, locomotive crane	1	2.40	..	....
Engineers, mixer	1	2.00	..	....
Engineers, roller	1	2.80	..	....
	1	2.40	..	....
	1	2.00	..	....
Engineers, steam shovel	..	....	3	22.58
Average—Engineers	29	2.39	11	19.27
Firemen	1	2.00	..	....
	1	1.60	..	....
	3	2.00	..	....
Firemen, compressor	..	....	1	12.69
Firemen, locomotive	..	....	1	12.41
Firemen, steam shovel	2	2.00	..	....
Firemen, traction engine	1	2.00	..	....
Average—Firemen	8	1.95	2	12.55
Foremen	11	4.00	5	22.58
	5	3.60	..	....
	1	3.50	..	....
	10	3.20	..	....
	2	3.00	..	....
	2	2.80	..	....
	1	2.60	..	....
	4	2.40	..	....
	1	2.00	..	....
Average	37	3.33	..	....
Harness maker	1	2.40	..	....
Interpreter	..	....	1	28.22
Janitor (office)	1	1.50	..	....
Laborers	13	1.60	..	....
	18	1.50	..	....
	208	1.40	..	....
	126	1.32	..	....
	83	1.25	..	....
	3	1.20	..	....
Average	451	1.36	..	....
Machinists	2	$2.00	..	....
Machinists' helpers	2	1.40	..	....
Master mechanics	..	....	1	56.45
Master mechanics' assistant	..	....	1	28.22
	..	....	2	24.84
	..	....	1	18.06
Mechanics	1	2.40	..	....
	2	2.00	..	....
Mechanics, crusher	1	3.20	..	....
Mechanics, steam shovel	..	....	1	28.85
Mechanics' helper	1	1.60	..	....
	1	1.40	..	....
Nipper wagon driver	1	1.25	..	....
Oilers, cableway	1	1.40	..	....
Oilers, compressor	..	....	2	9.23
Oilers, crusher	3	2.00	..	....
Paymaster	..	....	1	17.31
Pipe Fitters	2	2.40	..	....
	1	2.20	..	....
Plumber	1	2.40	..	....
Policeman	..	....	1	22.58
Powderman	..	....	1	10.16
Pumpmen	4	2.00	..	....
	1	1.40	..	....
Quarryman	1	1.60	..	....
Riggers	2	2.00	..	....
	1	1.80	..	....
	3	1.60	..	....
	9	1.40	..	....
Average	15	$1.55	..	....
Riggers, cableway	..	....	1	15.80
Rodman	1	2.00	..	....
Sleeping-house employees	..	....	1	10.38
	..	....	1	9.23
Stable boss	..	....	1	16.93
Stable men	6	1.50	..	....
Stenographer	..	....	1	23.08
Stone masons	1	3.00	..	....
	2	2.80	..	....
	7	2.40	..	....
Average	10	$2.54	..	....
Superintendents	..	....	2	$39.51
	..	....	1	33.87
	..	....	2	31.61
	..	....	1	25.96
" , assistant	..	....	1	28.22
	..	....	1	22.58
" , cableway	..	....	1	23.08
" , channeler	..	....	1	28.22
" , crusher	..	....	1	28.22
" , excavator	..	....	1	56.45
" , sanitation	..	....	1	28.22
" , steam shovel	..	....	1	23.08
" , teams	..	....	1	22.58
Average—Superintendents	..	....	15	$30.85
Tagmen	1	$1.60	..	....
	1	1.50	..	....
	1	1.40	..	....
Teamsters	3	1.60	..	....
	2	1.50	..	....
	26	1.40	..	....
	2	1.32	..	....
	2	1.25	..	....
	1	1.20	..	....
Average	36	$1.40	..	....
Telephone operator	..	....	1	$9.03
Timekeepers	..	....	1	32.31
	..	....	1	23.08
	..	....	1	19.62
	..	....	4	16.15
Average	..	....	7	$19.94
Waiters	..	....	1	$11.54
	..	....	2	10.38
	..	....	1	9.23
Watchmen, night	2	2.00	2	14.00
Watchmen, railroad crossing	1	1.25	..	....
Watchmen, steam shovel	1	2.00	..	....
Wheelwrights	1	2.80	..	....
	1	2.40	..	....
Wood choppers	2	2.00	..	....
Grand total	719	....	105	....

Coal Briquettes for Locomotive Fuel.

The regular use of briquetted coal as fuel for locomotives is very general on some European railways, and experiments in this direction have been made in this country. At the annual meeting of the International Railway Fuel Association, held in Chicago on June 21 to 23, the subject was dealt with in a paper by Mr. C. T. Malcolmson, Briquetting Engineer of the Roberts & Schaefer Co., Chicago. The first part of the paper was devoted to the history of coal briquetting, which was shown to date back to 1594, although the first satisfactory machine was built in 1842. The first briquetting plant in this country was installed at Port Richmond (Philadelphia) in 1870, and was of the Belgian roll type; it used a mixture of 92% anthracite culm and 8% clay as a binder. Since that time numerous experiments have been made and several attempts made to introduce the fuel, but with little commercial success as yet, although briquettes are used to some extent in a few cities, mainly for domestic purposes. According to a bulletin of the U. S. Geological Survey,* there were ten coal briquetting plants in this country in 1907, and their production for that year was 63,153 short tons, with a value of $244,942.

Various materials and compounds have been tried as the binding medium to unite the particles of pulverized fuel in a hard mass.† Mr. Malcolmson stated, however, that "except in special instances, pitch alone is used." It is essential that the amount should be reduced to a minimum and that it should be thoroughly mixed with the coal. In American practice, the amount varies from 5% to 10%, according to the process used and the character of the coal. The pitch should be both hard and tough. If the ordinary hard pitch is used (as produced in this country) the briquettes are brittle and produce considerable slack in handling. If the pitch is too soft, the fuel will be smoky.

As to this question of breakage in handling, it is stated that the percentage of dust in handling briquettes should not exceed 8%. In all the locomotive tests mentioned in the paper, this breakage was negligible when the briquettes were reasonably well made. The loss of heating value by weathering is very small. In regard to these two matters, the paper quoted the following statements:

Mr. W. H. V. Rosing, Mechanical Engineer, Missouri Pacific Ry.—It is our practice to store coal during the summer months when the coal cars on the system are not being fully utilized, and to use coal from storage piles later in the season when all the cars are required for commercial use. In this manner several hundred thousand tons are stored annually. During the summer of 1907 we lost 14,400 tons of coal by spontaneous combustion alone, which amounted to 8½% of the total amount stored. In fact, we can only store coal from certain mines on the system, and this must be stored in a certain manner to avoid loss by spontaneous combustion. With the briquetted fuel we could store coal from any of the mines without danger of spontaneous combustion, without deterioration or loss of volatile combustibles which occur on the surface of the ordinary coal piles.

Mr. A. W. Gibbs, General Superintendent of Motive Power, Pennsylvania Ry.—To observe the effect on briquettes of exposure to the weather, a number of the round and square briquettes were placed on the roof of the testing plant. After four months of exposure for the round and three months for the square briquettes no change whatever from their original condition was noticed. They appeared to be entirely impervious to moisture and were still firm and hard. They were little affected by handling. They were loaded at St. Louis in open gondola cars and shipped to Altoona, where they were unloaded by hand and stacked. They were handled a third time in taking them to the firing platform of the test locomotive. After these three handlings they were still in good condition, very few were broken, and the amount of dust and small particles was practically negligible.

In regard to the use of briquettes for locomotives, it is stated that briquettes made by a Schorr press at Stockton, Cal., were used on the San Francisco & Joaquin Valley Ry., but this plant was burned in 1905. The briquettes were made from lignite mixed with screenings of bituminous coal, and asphalt residuum from California petroleum was used as a binder. They weighed from 6 to 9 ozs. each, and are said to have been satisfactory, eliminating the objectionable features of raw lignite. On European railways this fuel represents from 15% to 40% of all the coal used. The briquettes weigh not more than 11 lbs. The specifications are very rigid; they vary, of course, in different countries, but Mr. Malcolmson gives the following as a summary of their requirements:

1. Briquettes shall be well made, sonorous, entire, with sharp edges, breaking with a clean cut, brilliant and homogeneous fracture.
2. Their cohesion shall be not less than 55% and they shall not soften at 50° C.
3. The briquettes shall ignite easily without causing dense black smoke, shall burn with a quick, bright flame and be consumed without disintegrating. The slag or clinker shall not adhere to the grates or tube sheets.
4. The briquettes shall not be hygroscopic nor contain more than 4% moisture. They shall contain between 15 and 22% volatile combustible, and not more than 11% ash. The coal shall have been freshly mined and be free from sulphur.
5. Coal tar pitch is the only binder specified; it must be practically odorless and limited to 10%.
6. The briquettes must be prismatic, with a square base; when specified they are from 3 to 11 lbs. in weight, according to kind of coal used, with a density of from 1.13 to 1.21.

A considerable amount of information on briquetting machinery and briquetted fuel has been published at different times in Engineering News*. The remainder of Mr. Malcolmson's paper deals largely with the railway experiments made under the direction of the U. S. Geological Survey, and an abstract of this part of the paper is given below. We omit the experiments of the Pennsylvania Ry., as these were described in our issue of July 2, 1908.

During 1905, 1906 and 1907, over 100 tests were conducted by the government on eastern and western railways to establish the relative value of briquetted and raw coal for locomotive use. There were 70 road tests made on the Burlington, Rock Island, Missouri Pacific and Chicago & Eastern Illinois railways, and 20 tests at the Altoona laboratory of the Pennsylvania Ry., under the direction of the writer, assisted by G. E. Ryder and Ralph Galt. The cooperation of the railway officials was secured so that these tests would be of value to them in comparison with other locomotive fuel tests. An abridgment of Mr. E. D. Nelson's report on the Pennsylvania Ry. laboratory tests has been published in Bulletin No. 363 of the U. S. Geological Survey.

The briquettes were made at the fuel testing plant at St. Louis and the details of manufacture have been reported in Bulletin No. 332 of the U. S. Geological Survey.† The object of the road tests was to discover, if possible, the problems to be encountered in the use of briquettes in actual practice, and wherein this practice was affected by good or faulty manufacture of the fuel. It must be remembered that the best efforts at the St. Louis plant could not produce uniformly satisfactory briquettes. The English machine was designed to meet European requirements and the American machine was in an experimental stage and made at best a product of varying quality. The problems involved in the manufacture of briquettes from our coals have been reported already. It is one object of this paper to show their value for railway use.

The first locomotive tests were made during the autumn of 1905 on locomotives of the Missouri Pacific Ry., between St. Louis and Sedalia, after having tested the burning quality of the briquettes in stationary locomotive boilers. The briquettes were made on the Johnson (English) machine from Arkansas semi-anthracite slack, and were tested in comparison with the Illinois lump coal regularly furnished for that division. The results given in a report by W. H. V. Rosing indicate an increased evaporation of 23% and a decreased consumption of fuel per 1,000 ton-miles of 3.7% in favor of the briquettes. The briquettes were broken in halves on this test, which created about 20% slack.

About this time, the New York Central Lines became interested in the use of briquetted coke breeze, and burned some briquettes made at the plant on the same machine. These were tested in freight and switching service by the Lake Shore & Michigan Southern Ry.

*Mineral Resources, 1907, pp. 223-228.
†Engineering News, June 25, 1908.

*Oct. 10 and Nov. 28, 1907; April 9, June 11, July 2, Oct. 15 and Dec. 10, 1908.
†Report of U. S. Fuel Testing Plant, 1906-7, pp. 36-46.

near Cleveland. The report of Mr. H. F. Ball, Superintendent of Motive Power, indicates that they were not satisfactory for heavy service, but had some advantages for switching, owing to the entire absence of black or gray smoke and very few cinders. They were hard to ignite, which, added to the high ash content of the coke, and the size of the briquettes, made it difficult to maintain a good fire.

Briquettes made from mixtures of gas-house coke and Illinois screenings were tested in switching service by the Missouri Pacific Ry. at St. Louis. They gave better results than those made from coke breeze. Even with those containing 50% coal, however, there was always an interval of time directly after firing when the steam pressure would fall. If the engine was working this was objectionable. No smoke was discernible even when the blower was shut off.

In June, 1906, the Rock Island Ry. became interested in the use of briquettes and 100 tons of Hartshorne (Ind. Terr.), slack were briquetted and shipped to Chicago for test. The report of Mr. C. A. Seley compared these results with Illinois lump coal used in freight service and indicated an average in the coal consumption of 26.2% in favor of briquettes. The observer's notes on these tests stated:

> The briquettes did not "honeycomb" the tube sheets sufficiently to give any trouble, and this slag was not as hard to remove as with Illinois coal. The ashes from the briquettes did not clinker. The nozzle could be increased ¼-in. and still produce a sufficient draft. This fuel burns with an intense heat, much like coke, and the depth of the fire is easily regulated. On arriving at Joliet, an inspection showed fire next to the grate, which would not be the case with coal. A slight puff of black smoke appeared only when briquettes were fired; this almost immediately disappeared, a desirable feature for suburban service.

The general interest awakened by these preliminary tests warranted the government in making more extensive records, and the cooperation of the Rock Island, Missouri Pacific, Burlington and Chicago & Eastern Illinois railways was sought. The samples, varying in weight from 100 to 400 tons, were shipped to St. Louis and briquetted on the English and Renfrow machines in about equal amounts, using from 6 to 9% of water-gas pitch binder. The briquettes were consigned to the railway and loaded through its coal chutes in the usual manner in which coal is handled. Where the briquettes were soft, care was taken to handle them with coke forks in weighing onto the tender. The water tanks were calibrated and the water measured as used. Flue gas analyses and front-end and furnace temperatures were taken during the run. Carefully selected samples of fuel, ash and cinders were shipped to St. Louis and analyzed. Steam pressure, feed water temperature, leakage, smoke, condition and thickness of fuel bed, method of firing and draft were recorded. The same engine, and (as nearly as possible) the same crew were furnished by the railway for all tests on that road. At the end of the run the condition of the engine was noted, and the test written up.

Comparative tests were made on lump coal from the same mine as the slack shipped from Oklahoma, Kansas and Missouri. A condensed summary of the results of these tests is given in the accompanying table. A record of tests on Carterville lump and mine-run coal made by the Burlington Ry. is included for comparison with the tests of briquetted slack from the same district. Noting the equivalent evaporation per pound of fuel as fired, it will be observed that in nearly all cases the rate is in favor of briquettes.

In the case of the tests of Illinois coal on the Burlington Ry., all of the fuels are from different mines and are therefore of comparative value only when their cost is taken into account. The Burlington tests with Missouri coal show practically the same results with briquettes and lump coal, while the Indiana coals offer the same problems in briquetting and show the same characteristics in burning as Illinois coals.

The most representative tests, and therefore the most accurate expression of what may be accomplished with well made briquettes, are the tests made on the Rock Island and Missouri Pacific railways with Oklahoma and Kansas coals. The Rock Island tests show an increased equivalent evaporation of 8% and increased boiler efficiency of about 15%, while the Kansas briquettes show 25% increased evaporation over lump coal. The causes to which may be attributed the variation in results of the various fuels tested are discussed further on.

The density of the briquettes is of prime importance. Harder briquettes do not break up so easily and they burn more slowly in the fire. By this means the volatile combustible is driven off more nearly at the rate at which it can be burned with greatest economy, and the briquettes form coke during the process of combustion even though made with an otherwise non-coking coal. This is more essential with high volatile than with high carbon coals.

With the harder high volatile coals of Illinois, the tendency of the lump coal to break up in the fire is less than with the more friable low volatile coals of the Appalachian field. The eastern coals also produce much more slack in handling, so that the main objection to their use as a railway fuel is the percentage lost through the stack and the coking of the coal in a mass in the firebox. The Arkansas and Oklahoma coals have similar characteristics. With well made briquettes from these good coking coals, the briquettes coke separately and do not run together in the fire.

It was thought necessary to break the Arkansas 4-lb. briquettes before firing, but the same briquettes made from Hartshorne and Loydell coals were fired whole and burned with good results. The 8-ounce briquettes did not give as loose a fire, and could not be fired with such a heavy bed when made from Illinois coal. It must be observed in this connection, however, that the more friable coals can be made into better briquettes with less pressure than the other coals tested. The whole value of the briquette is due to its uniform size and freedom from slack in handling. These statements are born out in the tests of Illinois and Missouri coals, where the lump coal did not break up badly in handling, while the briquettes used on these tests produced at least 15% slack, which was naturally very fine; a considerable portion being lost through the stack. The fuel could not be wetted down, as uniform conditions had to be maintained for test purposes.

These coals do not readily coke, so that while a poorly made briquette would hold together if made from the eastern coal, it would tend to disintegrate when made from these coals. It was necessary, therefore, to fire with a thin bed, as the fine coal would cause heavy clinker to form and cut off the draft when a thick fire was carried. It was the usual experience that the briquettes made no objectionable clinker and the ash was finely divided and easily shaken through the grates. This is to be expected from the manner in which the coal is prepared before briquetting, and from the uniform distribution of the slag-producing elements of the ash (such as iron pyrites) throughout the briquette.

The reduction in cinders and sparks by briquetting depends on the quality of the coal as well as the density of the briquettes. Certain coals, like the Loydell coal, produce a fine scale of coke in burning which is often loosened from the surface of the briquette by the action of the draft and carried partially burnt through the stack. With Hartshorne and Arkansas coals the coking is very different in character, probably due to the higher ash content, and these coke scales are scarcely noticeable. The same difference was noticed in burning briquettes made from Pocahontas coal and "bone coal" picked from the mine-run coal. The latter was high in ash and the scales were greatly reduced. The results at Altoona showed no appreciable reduction in the weight of cinders from briquettes, but a decided reduction in their calorific value.

In general the following advantages may be claimed for briquettes made from bituminous coal over the same coal not briquetted:

1. Comparative absence of smoke.
2. Uniformity of size and quality.
3. Less loss of fuel in ash.
4. Increased furnace and boiler efficiency.
5. Reduced consumption of fuel per ton-mile.
6. More fuel can be burned per sq. ft. of heating surface, hence greater capacity.
7. Less slack in handling fuel.
8. Less clinker and cinders.
9. Longer life of grates.
10. Fires can be kept up for longer periods without cleaning.
11. Less cleaning of tubes.
12. Less labor in firing, hence
13. Greater efficiency of fireman.
14. Less draft needed.
15. More uniform steam pressure.
16. Steam pressure can be increased more rapidly.
17. No liability to spontaneous combustion.
18. Availability for storage without deterioration.

Humidity and Mine Explosions.

By H. N. EAVENSON,† M. Am. Inst. M. E.

It has long been a matter of common opinion among mining men that mine explosions are more frequent during the colder, or winter months, than during the warmer ones, and it is a matter of common knowledge among them that the air-ways and road-ways in most mines are much drier and are more inclined to be dusty during the winter than during the summer. In many mines, places which are wet and sloppy in the summer are dry and sometimes dusty during the winter. These changes, of course, can only be due to atmospheric conditions, and are caused by differences in temperature and humidity. Until recently, however, very little attention has been paid to the part that atmospheric conditions may play in mine explosions, or, rather, to the effect they may have in rendering mine conditions peculiarly dangerous, and in spreading and rendering more disastrous the effects of what would otherwise probably have been small explosions.

To show the difference in mine conditions during summer and winter months, I have collected the results of 24 observations of hygrometric conditions at different times of the year in several different mines, mostly located in the Pocahontas coal region, in McDowell County, W. Va., one being a shaft mine and the others drift. All of these are mines of fair size, but none of them has been in operation more than six years, and none of them has the amount of air in circulation that it will ultimately require. The conditions given are not extremes of temperatures, but are fair averages for the seasons of the year in which they were taken. The temperatures and humidities are not averages for the entire day, but are averages of two determinations taken at the same time during the day.

The figures showed that, during the winter months, water is removed from the mines, by the ventilating current, at rates of from 21 to 69 tons in 24 hours, and that in the summer months it is deposited in the same mines at rates of from 12 to 33 tons in 24 hours. There were extreme differences shown in the amount of aqueous vapor present in the air of one mine, between summer and winter conditions, of more than 100 tons in 24 hours.

Unless one is accustomed to considering the amounts of moisture present in the atmosphere, at all times, these quantities are startling, but the observations can easily be duplicated by any one interested at trifling expense. Can any one doubt that, if coal dust by itself is explosive as now seems proved, the removal of these amounts of moisture from the mine air, in mines apt to be dusty, may remove the balance and convert a mine ordinarily safe into one liable to cause a terrific explosion, if anything should happen to raise the temperature to the explosion point of the dust?

For the purpose of determining the relative occurrence of explosions, I have compiled the explosions caused by gas or dust in which five or more fatalities have occurred, and which have been officially reported in Canada, Mexico, and the United States. No explosions or fatalities caused by fires, wrecks, falls, etc., have been included, as it is inconceivable that atmospheric conditions could have affected such occurrences to any appreciable extent. By far the larger proportion of explosions and of fatalities has occurred in the eastern part of the United States, in the Appalachian region, as was to be expected, considering the relative production and number of mines of this section and of the remainder of the country. An analysis of these explosions sepa-

*From a discussion of a paper on "Humidity and Mine Explosions," by Mr. Carl Scholz, M. Am. Inst. M. E., and printed in the "Bulletin" of the American Institute of Mining Engineers, issue of June, 1906.

†Chief Engineer, U. S. Coal and Coke Co., Gary, McDowell County, West Virginia.

TABLE SHOWING RESULTS OF COMPARATIVE TESTS OF COAL AND COAL BRIQUETTES FOR LOCOMOTIVE FUEL.

Railway	Chicago, Bur. & Quincy				C., R. I. & P.		Missouri Pacific			Chicago & E. Ill.		Chicago B. & Q.	
Coal for test	Carterville District, Illinois				Hartshorne, Okla.		Pittsburg, Kan.			Sullivan Co., Ind.		Bevier, Mo.	
Fuel tested	Briquettes Washed	Briquettes Unwashed	Coal 3-in. lump	Coal Mine run.	Briquettes Unwashed	Coal Lump	Briquettes Washed	Briquettes Unwashed	Coal Lump.	Briquettes	Mine run coal	Briquettes	¾-in. lump coal
Proximate analyses; fuel as fired	....	....	....	....	....	....	....	....	....	....	....	....	....
Moisture	5.67	5.41	5.59	4.70	2.1	2.54	3.44	2.49	5.47	7.14	13.86	7.69	11.40
Vol. combustible	31.09	31.86	32.67	35.04	35.65	36.98	33.21	31.15	29.15	36.02	32.18	32.86	33.55
Fixed carbon	30.75	51.38	52.80	47.14	50.74	53.97	52.45	47.33	49.81	44.18	41.90	39.52	42.12
Ash	12.49	11.35	8.94	13.12	11.51	6.51	10.90	19.03	15.57	12.66	12.06	19.93	13.93
Sulphur	1.11	1.87	....	....	1.63	1.75	3.67	4.43	4.80	3.63	3.48	4.50	5.78
B. T. U. per lb. fuel as fired	11,969	12,163	....	....	13,015	13,681	13,033	11,713	11,422	11,711	10,553	10,429	10,556
Fuel consumed per sq. ft. of grate surface per hour, actual	73.7	73.2	80.9	85.7	44.3	55.2	75.0	78.2	92.1	48.0	53.0	71.0	63.0
Water evap. per lb. of fuel	8.66	8.36	8.99	8.15	9.00	8.34	8.84	8.89	7.13	7.25	6.77	7.00	6.81
Water evap. per lb. of dry fuel	9.09	8.86	9.52	8.56	9.20	8.56	9.15	9.12	7.54	7.79	7.86	7.58	7.91
Equivalent evap. per sq. ft. of heat. surface per hour	9.97	9.94	11.60	11.20	6.96	8.02	9.49	9.97	9.42	6.56	6.80	6.78	6.76
Boiler HP. developed	792	780	912	873	522	599	813	854	809	469	485	604	604
Boiler efficiency	69.5	66.5	....	....	66.8	58.7	65.5	75.8	60.2	59.6	62.4	64.8	64.2

rately including in the Appalachian region, Nova Scotia, Pennsylvania, Virginia, West Virginia, Tennessee, and Alabama, is given in Table I.:

TABLE I.—NUMBER OF EXPLOSIONS IN WHICH FIVE OR MORE FATALITIES OCCURRED, AND OF FATALITIES CAUSED BY GAS OR DUST, IN THE APPALACHIAN REGION OF NORTH AMERICA. (From Oct. 2, 1871, to March 28, 1908, by months.)

Month.	No. of explosions.	No. of fatalities.	Average No. of fatalities per explosion.	Percentage of Explosions.	Percentage of Fatalities.
January	8	468	58.5	9.4	18.3
February	10	343	34.3	11.8	13.4
March	12	276	23.0	14.1	10.8
April	4	30	7.5	4.8	1.2
May	11	341	31.0	12.9	13.3
June	3	35	11.7	3.5	1.4
July	5	142	28.4	5.9	5.6
August	2	12	6.0	2.4	0.5
September	6	52	8.7	7.0	2.0
October	9	85	9.4	10.6	3.3
November	8	79	9.9	9.4	3.0
December	7	698	99.7	8.2	27.2
Total	85	2,561	30.1	100.0	100.0

To ascertain the average atmospheric conditions over the area covered by the Appalachian region, I obtained from the U. S. Weather Bureau the average monthly temperatures and the average monthly actual humidities for each year from 1896 to 1907, inclusive, for the following places: Lynchburg, Va.; Pittsburg, Pa.; Elkins, W. Va.; Knoxville, Tenn., and Atlanta, Ga.; these stations being taken as covering the region fairly and being the ones for which records could best be obtained, and from these data Table II. was compiled.

TABLE II.—AVERAGE MONTHLY WEIGHT AND TEMPERATURE OF AQUEOUS VAPOR IN AIR, 1896 TO 1907, INCLUSIVE. FOR THE SOUTHERN APPALACHIAN REGION.

Average weight, in grains per cu. ft.		Average temperature, in degrees F.	
January	1.81	January	36.1
February	1.64	February	34.4
March	2.57	March	47.1
April	3.01	April	53.6
May	4.56	May	65.5
June	6.02	June	71.8
July	6.80	July	75.7
August	6.77	August	74.7
September	5.40	September	69.0
October	3.62	October	57.5
November	2.50	November	46.3
December	1.88	December	37.1

During the five low-humidity months, 52.6% of the number of serious explosions and 62.4% of the fatalities caused by them, have occurred, and the average number of fatalities per explosion occurring in these five months was 38.3, against an average of 25.5 for the remaining seven months and of 32.2 for the year.

Table I. shows that, in the Appalachian region, during the five low-humidity months, or 41.7% of the period covered by the table, 52.9% of the number of serious explosions, and 72.8% of the fatalities caused by such explosions, have occurred, and that the average number of fatalities per explosion occurring in these five months is 41.4, against an average of 17.4 for the remaining seven months, and of 30.1 for the year.

These figures indicate that more serious explosions do occur during the colder or low-humidity months than during the warmer ones, but that the disproportion in numbers is not as great as is usually supposed.

To see if this apparent tendency for explosions caused by gas or dust to occur more frequently during the low-humidity months extended to all such explosions, or only to the more serious ones, Table III. covering all of the data available, has been compiled.

TABLE III.—COMPARATIVE NUMBERS AND FATALITIES OF EXPLOSIONS OCCURRING DURING FIVE COLDER MONTHS AND REMAINDER OF YEAR IN PENNSYLVANIA, WEST VIRGINIA AND INDIAN TERRITORY.

	Pennsylvania.		W. Virginia.		Indian Ter.	
	Nov.-Mar. Inclusive.	Remainder of Year.	Nov.-Mar. Inclusive.	Remainder of Year.	Nov.-Mar. Inclusive.	Remainder of Year.
Percentage of time	41.7	58.3	41.7	58.3	41.7	58.3
Percentage of explosions	41.6	58.4	58.0	42.9	47.8	52.2
Percentage of fatalities	58.9	41.1	83.3	16.7	43.5	56.5
Av. number fatalities per explosion	5.2	2.8	17.4	4.8	1.2	1.4

From this study it is to be concluded that in the history of coal mining in North America serious explosions of gas or dust have occurred more frequently during the five low-humidity months than during the rest of the year, and that the explosions occurring during those months have been more severe and have occasioned more fatalities than the others.

THE PENNSYLVANIA R. R. STATION AT NEW York City, described in our issue May 24, 1906, p. 567, is nearing completion. On July 31 the last stone was laid on the exterior. Work on the interior is progressing well. It is now expected that all through trains of the Pennsylvania into New York will be entering the station by the summer of 1910.

A CONFLAGRATION IN OSAKA, JAPAN, July 31, burned over an area of 16 square miles, destroying 13,000 buildings. Owing to a strong breeze and the failure of the water-supply, the fire burned for 26 hours before being gotten under control.

A HEAD-ON COLLISION between two trains on the Spokane & Inland Ry. (electric), July 31, near Coeur d'Alene, Idaho, derailed several coaches and caused the death of ten persons and the injury of 60 others. The trains were made up of five cars each and were running at a rate of 15 mi. per hr. at the time of the collision.

A POWDER-MILL EXPLOSION wrecked two of the buildings of the Du Pont Powder Works at Gibbstown, N. J., July 29, and killed one workman. The explosion occurred in the gun-cotton house and completely destroyed it. A nearby structure known as the "Nyalite" building was destroyed by fire which was started by the explosion.

OBSTRUCTED VENTILATION IN A COAL MINE at Pittsburg, Kan., July 30, resulted in 40 miners being overcome by gas. Three of them are reported to have been fatally injured. The accident is ascribed to deliberate interference with the ventilation by enemies of the Central Coal & Coke Co., which operates the mine.

AN EXPLOSION OF GASOLINE at St. Paul, Minn., July 31, killed six persons and injured as many others. The four-story building in which the explosion occurred was partially wrecked and a fire started in the ruins. The accident occurred on the second floor where experiments were being made with a device to be used in connection with automobile tanks.

AN EARTHQUAKE IN MEXICO, July 30, affected from coast to coast the strip between Queretaro on the north and Oaxaca on the south. Fourteen deaths were reported and in addition about 20 persons were severely injured. The towns that suffered most heavily were Chilpancingo and Acapulco, both in the State of Guerrero. At these places, many buildings were overthrown and the entire populations are reported to have taken refuge in the open. At Mexico City two shocks were felt in close succession, the first shock beginning at 4.15 a. m. The second shock was the more severe and lasted 90 seconds. More than 2,000 houses in Mexico City were so damaged that they are untenantable. Reports state that, throughout large areas of the affected district, practically all growing crops were killed by the earthquake and a heated condition of the ground which followed it.

THE PHILADELPHIA BUILDING COLLAPSE noted in our issue of July 22, 1909, p. 107, has numbered two more victims, the total number of those killed being nine.

THE WRIGHT AEROPLANE, driven by Orville Wright, completed the contract requirements of the Signal Corps of the U. S. Army in a ten-mile cross-country flight with a passenger, July 30, between Fort Myer and Alexandria, Va. The course was over rough and wooded country but was made without incident. The average speed is reported to have been 42.58 mi. per hr. The trip was in opposite directions over a five-mile course, and this average speed is obtained from records of 37.74 mi. per hr. against the wind and 47.43 with it. The government requirements were for an average speed of 40 mi. per hr. with a bonus of $2,500 for each mile per hour above that. Thus the Wright brothers will receive $30,000 for their flyer.

A ZEPPELIN giant rigid dirigible balloon made a trip of 220 miles from Friedrickshafen to Frankfort, Germany, on July 31. The average speed was 21 mi. per hr. This voyage, while not the longest made by Count Zeppelin, is considered the most successful, as no accident occurred and the trip was made part of the time against strong head winds. In fact, at one time, the wind prevented all progress, though the propellers were driven at a speed that normally would have given the airship a speed of 40 mi. per hr.

An attempt was made to reach Cologne from Frankfort on Aug. 2, but a hard storm prevented approach nearer than 30 miles.

STREET RAILWAY ACCIDENTS in New York City are decreasing, according to the monthly report compiled by the Public Service Commission. In our issue of Sept. 10, 1908, p. 277, we published a table classifying these accidents for the first six months of that year in which the average monthly figures were as follows: Total accidents, 4,788; total injuries, 2,982; serious injuries and deaths included in the above, 212. The corresponding figures for April, 1909, just issued are: 4,170, 2,494 and 177, respectively.

SURREPTITIOUS ENTRANCE TO THE ALASKA-Yukon-Pacific Exposition at Seattle was obtained for some time by considerable numbers of people, it is reported, by means of a sewer which had recently been built through the exposition grounds. A manhole conveniently located in the woods gave access to the grounds.

A NEW PHENOMENAL TUNNELING RECORD is reported from the Loetschberg Tunnel. Record rates of advance had already been made in the newly-started north heading during April and May, 1909, but in June, 1909, the wonderful advance of 302 m. or 990 ft. was made in this heading. The rock was a limestone. During the same month the south (Goppenstein) heading advanced 166 m. (545 ft.) in crystalline schists crossed by dykes of porphyry. [After "Schweizerische Bauzeitung."]

THROUGH A BIG SEWER BY AUTOMOBILE was the experience of city officials and others at Baltimore, Md., a few days ago, when 16 automobiles passed for nearly six miles through the outfall sewer which leads from the city to the disposal works now under construction for Baltimore. Mr. Calvin W. Hendrick is Chief Engineer of the Baltimore Sewerage Commission. The M. A. Talbott Co., American Bldg., Baltimore, Md., is the contractor for the outfall sewer.

DESTRUCTION OF ROADS by the old-fashioned carts in use in Cuba is charged by the government reports of that republic. The particular cart against which complaint is made is called a "carreta." It is a clumsy affair with two large narrow-tired wheels set on the axle in such a manner as to permit a side play of several inches. When the wheels are caught in a soft place the cart is swung from side to side until a rut is made large enough to permit the cart being pulled out. Ordinarily these wagons are loaded with 4 or 5 tons of material which causes a tire pressure as high as 2,000 lbs. per inch of width of tire, an extremely high load, especially when it is concentrated on a narrow tire, and one which soon cuts through the best of road surfacing. Efforts have been made to legally prohibit the use of the carts but to date they have not been successful.

THE AMERICAN EXPOSITION IN BERLIN will be held during the months of April, May and June, 1910, in the well-known Exposition Palace. Baron R. von Brandenstein, President and General Manager of the Exposition, Berlin, is chairman of the German Advisory Committee and Dr. George F. Kunz, of New York City, is chairman of the American Advisory Committee. An appeal has been issued by a committee of prominent American business men to make the exposition worthy of American manufacturers. They express the opinion that this exposition will offer to American industries an excellent opportunity to exhibit their products in Germany and to increase their foreign sales and that the exposition as planned will improve the commercial relations between the German and American nations. The American headquarters, of which Mr. Max Vieweger is manager, are in the Hudson Terminal Buildings, New York City.

AMOUNT OF COAL IN OHIO.—Mr. M. R. Campbell, of the U. S. Geological Survey, in his report on the coal fields of the United States, estimates that there were 86,028,000,000 short tons in the original coal supply of Ohio. The total production of the state to the close of 1908 was 519,039,997 short tons, of which the 1908 output amounted to about 5%. This total production represents an exhaustion of 779,000,000 tons, or 0.9% of the estimated original supply.

IRRIGATION IN PENNSYLVANIA is being tested on the farm of Henry Fusselman, near Spring Creek, apparently at the instance of the Allentown Rolling Mills, of Allentown, Pa. It is stated that the idea was suggested by Mr. R. H. Aldrich, who is engineer of the electric pump department of the mills named. A 500-gal. pump has been belted to a 15-HP. gasoline engine and forces water through two 5-in. mains, from which canvas hose and ditches are being used to distribute water over potatoes, corn, and other crops on a 500-acre farm. The dry weather of the past few weeks has made this trial opportune.

THE COMMISSION FORM OF CITY GOVERNMENT was adopted by Kansas City, Kans., on July 14. At an election on the same subject held last year, the commission plan was defeated by a majority of 882. It carried this year by a majority of 1,489 out of a total vote of 7,211. The change in popular sentiment is attributed to state legislation meanwhile, which removed some alleged defects in the general law authorizing the commission plan of government in Kansas. It is reported that this plan has now been adopted by Anthony, Hutchinson, Independence, Leavenworth and Wichita, as well as Kansas City. The population of Kansas City, Kans., was 51,418 by the census of 1900; local estimates place it at double or more that figure at present.

THE UNIFORM CLASSIFICATION OF EARNINGS and expense accounts of water transportation lines has been under consideration for a year or two past by the Interstate Commerce Commission and some of the various water transportation lines. The American Steamship Association appears to be the chief corporation which has cooperated thus far with the Interstate Commerce Commission. The Standing Committee on Accounts of the association just named has made up a "tentative classification of operating revenues and of operating expenses." This has been printed as Circular No. 27, Accounting Series of the Interstate Commerce Commission.

TUNGSTEN-FILAMENT ELECTRIC LAMPS have just been placed on the market by the General Electric Co., of Schenectady, N. Y. (lamp works at Harrison, N. J.) for use on 200 to 250-volt circuits. There has been an unsatisfied demand for such types since the introduction of the 125-volt type, on account of the much lower efficiency of the best carbon-filament lamp available for the higher voltages. These carbon lamps had a power consumption ranging from 3.1 to 3.8 watts per c. p., while the new tungsten lamps operate at about 1.25 watts, or the same as the low-voltage types. The brittle nature of the tungsten filament has heretofore made its production impracticable in sufficiently long and fine filaments for high voltages. It is to be expected that the 250-volt lamps are not quite as rugged as the 125-volt types and these have required great care in handling and shipping.

GRADE-CROSSING IMPROVEMENT has been conducted very actively on the lines of the Long Island R. R., partly by joint action with public authorities. In the last five years it has abolished 22% of its grade crossings. The total number either abolished or previously protected is 51%. This is a higher percentage than other railways in New York State can show, which fact is in part explained by the large mileage which the Long Island operates in the Metropolitan district. The percentages of protected crossings on other important New York State lines are quoted for comparison as follows: New York Central, 43%; Lackawanna, 43%; Erie, 31%; Delaware & Hudson, 30%; Ontario & Western, 30%; Lehigh Valley, 20%. Roughly half of this improvement has been accomplished in the last five years. The total number of crossings of railways with highways in the state is 10,544, of which 3,676 are now protected.

MAXIMUM TEMPERATURES IN BEEHIVE COKE ovens have been investigated by Mr. J. R. Campbell, of the H. C. Frick Coke Co., Scottdale, Pa. A number of pyrometric tests were made on various types of beehive ovens in the Connellsville region. In an article in the "Engineering and Mining Journal" of July 17, 1909, Mr. Campbell presents the following conclusions drawn from these tests:

Maximum temperature attained in:

1. Small type of beehive oven with coal of low volatile matter (comparatively), 2,200° to 2,400° F.
2. Large type of beehive oven and high volatile matter (comparatively), 2,400° to 2,600° F.
3. Large type of beehive oven and high volatile matter (comparatively) with flue system for operating boiler plant, 2,700° to 2,900° F.

From which we deduce (a) that a low-grade refractory will serve its purpose in No. 1, hence the longevity of this type of oven; (b) that this same material used in No. 2 fails of its purpose, hence come the many and manifold troubles of the present coke-oven builder and operator, caused by falling ovens; (c) that only the highest grade refractory will stand the heat of No. 3.

THE BALTIMORE SEWAGE TREATMENT WORKS, according to the just-issued 1908 report of the Baltimore Sewerage Commission, will include hydraulic tanks and percolating filters with nozzles designed to throw a spray which will cover a rectangular surface. This feature of the nozzles, combined with varying heads, is expected to make it possible "to utilize almost every foot of the filter beds." The experiments at the sewage-testing station concluded some months ago indicate that the secondary sand filters, recommended by the advisory engineers under the very stringent instruction given them, will be unnecessary. Provision will be made for secondary treatment of the sewage with chlorine as a disinfectant, if that proves necessary. Mr. Calvin W. Hendrick, M. Am. Soc. C. E., is Chief Engineer of the Baltimore Sewerage Commission.

TO PREVENT DUST RAISING by motor vehicles is the object of an invention by Mr. Eugene Josenhaus, of Barcelona. A description of this device, which was given originally in the London "Times" and condensed in the "Surveyor" of the same city, is as follows:

The wheels of the vehicle are enclosed in a case which nearly reaches to the ground, the lower part being composed of india-rubber, canvas, or other flexible material. The edge of this screen is provided with metallic balls, which almost touch the road. From the rear part of this screen tubes are led to a suction fan, which is driven from either the engine, shaft or axle, and communicates with the exhaust. By means of compressed air a fine jet of water is sprayed on to the dust which is drawn from the case enclosing the wheels, and thus it is prevented from rising in the air. It would be rash to assert that this invention does not contain the possibilities, the germ, of prevention, but until more information is forthcoming with respect to its practicability it would certainly not be wise to place much reliance upon it as the solver of the great dust problem. As at present advised it does not appear feasible that the solution will come from any such invention as this, however ingenious it may be.

A CABLE RAILWAY OF 66% GRADIENT was recently opened for traffic in the Tyrolean Alps. It is near the village of Bozen, and leads up the mountainside to the Virgl terrace. The line is singletrack, with a turnout at mid-length. The gage is 1 meter. The source of power is a 55-HP. electric motor at the upper landing. This is operated by alternating current at 550 volts, supplied by a high-tension transmission-line from a hydraulic power-plant. The cars have hand and automatic brakes, the latter having been proven, by tests, to be capable of stopping the car in less than 5 ft.

THE DAMAGING EFFECT OF FIRE on poorly-made concrete block was clearly shown in a recent fire in a building of that type in Murfreesboro, Tenn., reported on by the Tennessee Inspection Bureau. The building was of ordinary timber joist construction, 60 × 115 ft. in plan, and two stories high with a basement. The walls were of 10-in. single-opening hollow concrete block, with inner and outer shells ranging from 2 to 4 ins. in thickness. The contents of the building were hay, sacked grain, feed, cotton and like material, all stored on the first floor. The second floor was a skating rink, but as it was not in use at the time the only load on the walls was the dead load of the second floor and roof. The fire was not of exceptional heat as some of the timber joists and the sacks of seeds were not destroyed, but the effect on the walls was most disastrous. All of the walls above the first story collapsed and the front and rear walls were thrown down for their entire height.

Examination of the blocks after the fire showed that they were made of good aggregate, but that little sand was used and that the cement content was entirely too low. In consequence the blocks were very porous and weak. In addition the poorest of mortar joints were used so that even in cases where the blocks stood up the joints failed, with subsequent collapse. In nearly every block the thin web connecting the front and rear walls was found to be cracked through. In conclusion the report says that the composition of the blocks was little better than slacked lime.

This fire bears out in detail the experimental tests made by the U. S. Geological Survey and reported in our issue of July 15, 1909, pp. 77, 80, in that it shows the part that expansion plays in the behavior of concrete blocks under fire. The real fireproof qualities of dense and thick-webbed concrete block are assured, but this very assurance gives a false feeling of security to those owners who are using cheap, poorly-made block.

Personals.

Mr. E. C. D'Yarmett, an engineer and contractor of Bartlesville, Okla., has removed his headquarters to Oklahoma City.

Mr. W. J. C. Kenyon has resigned his position as Vice-President and General Manager of the Illinois Tunnel Co., Chicago, Ill.

Mr. Chas. H. Kluegel, M. Am. Soc. C. E., has become Chief Engineer of the Hilo R. R., of Hawaii, in charge of the Hakalau extension.

Mr. H. W. Burkheimer has been appointed Master Mechanic of the New Orleans Great Northern R. R. to succeed Mr. F. Schledorn, Acting Master Mechanic, resigned.

Mr. A. S. Ingalls, Assistant General Superintendent, at Cleveland, Ohio, of the Lake Shore & Michigan Southern Ry., has been appointed General Superintendent of the Chicago, Indiana & Southern R. R., with headquarters at Gibson, Ind., to succeed E. Ryder, deceased.

Mr. J. G. Neuffer, Superintendent of Machinery of the Illinois Central R. R. and the Indianapolis Southern R. R., has resigned. To succeed him, Mr. J. E. Buker has been appointed Superintendent of the Car Department and Mr. R. W. Bell has been appointed Superintendent of Machinery in charge of the locomotive department.

Mr. E. G. Connette, General Manager of the Worcester (Mass.) Consolidated Street Ry. Co., has been appointed Transportation Engineer for the New York Public Service Commission, First District, at a salary of $8,000 per year. He will have general charge of inspection of equipment and transit, of the investigation of accidents and of technical electrical matters.

Mr. W. K. Hatt, Assoc. M. Am. Soc. C. E., Civil Engineer of the Forest Service, will represent the Forest Service at the congress of the International Association for Testing Materials to be held at Copenhagen, Denmark, Sept. 7-11, and will investigate and report on certain problems in wood preservation in Germany. His European address will be c/o Al Peters, 6 Unter Den Linden, Berlin.

Obituary.

William Warren Lyon, Jr., Assoc. Am. In[illegible] E. E., died July 30 at his home in New York City. [illegible] Lyon was a graduate of Columbia University in th[illegible]ass of 1906. At the time of his death he was in the [illegible]loy of the New York Public Service Commission.

Henry M. Putney, Chairman of the New [illegible]pshire State Board of Railway Commissioners, died J[illegible] 31 at his home in Manchester, N. H., at the age of [illegible] years. He had held the chairmanship of the State [illegible]ard of Railway Commissioners continuously since 18[illegible]

Carleton H. Wells, President of the Texas [illegible]silithic Co. for the past five years, died July 18 at his [illegible]me in Dallas, Tex., aged 44 years. He was born [illegible] Lake Mills, Wis., and was for several years engaged [illegible] a contractor on the construction of railways, build[illegible]gs and water systems in that state. About ten [illegible]rs ago he went to Massachusetts and interested himself in the paving industry. He removed to Shreveport, La., in 1904 and changed his headquarters from that [illegible]city to Dallas, Tex., the following year.

David H. Gildersleeve, M. Am. Soc. M. E., died July 30 at the home of his mother in Brooklyn, N. Y. Mr. Gildersleeve was born at Tenafly, N. J., in 1867, and graduated at Stevens Institute in 1889. A few years after his graduation he enlisted in the U. S. Corps of Engineers and, with the rank of first lieutenant, served throughout the Spanish-American war. After the close of the war he was detailed to the Department of Havana, under General Ludlow, and took part in the work of putting that city in a sanitary condition. Five years after the close of the war he left the Engineer Corps and became Sales Manager and Assistant to the President of the C. W. Hunt Co. About one year before his death he became a partner in the firm of Waters, Gildersleeve & Colver, of New Brighton, Staten Island.

Engineering Societies.

COMING MEETINGS.

NATIONAL IRRIGATION CONGRESS.
Aug. 9-14. Annual meeting at Spokane, Wash. Secy., B. A. Fowler, Phoenix, Ariz.

AMERICAN BOILER MANUFACTURERS' ASSOCIATION.
Aug. 10-12. Annual convention at Detroit, Mich. Secy., J. D. Farasey, E. 37th St. & Erie R. R., Cleveland, Ohio.

LEAGUE OF AMERICAN MUNICIPALITIES.
Aug. 25-27. Annual convention at Montreal, Can. Secy., John MacVicar, Des Moines, Iowa.

ASSOCIATION OF EDISON ILLUMINATING COMPANIES.
Aug. 31-Sept. 2. Annual meeting at Briarcliff Manor, N. Y. Secy., D. L. Huntington, Spokane, Wash.

TRAVELING ENGINEERS' ASSOCIATION.
Sept. 7-10. Annual convention at Denver, Colo. Secy., W. O. Thompson, N. Y. C. Car Shops, East Buffalo, N. Y.

NEW ENGLAND WATER-WORKS ASSOCIATION.
Sept. 8-10. Annual convention at New York City. Secy., Willard Kent, 715 Tremont Temple, Boston, Mass.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
Sept. 14-16. Annual convention at Atlantic City, N. J. Secy., Frank P. Foster, Corning, N. Y.

MICHIGAN GAS ASSOCIATION.
Sept. 14-17. Annual meeting on board steamer sailing from Detroit, Mich. Secy., A. P. Ewing, Gas Office Bldg., Detroit, Mich.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Sept. 16-Oct. 12. Annual convention and excursion on special train starting at Chicago, Ill. Secy., R. W. Raymond, 29 W. 39th St., New York City.

AMERICAN STREET & INTERURBAN RAILWAY ASSOCIATION.
Oct. 4-8. Annual convention at Denver, Colo. Secy., Bernard V. Swenson, 29 W. 39th St., New York City.

RAILWAY SIGNAL ASSOCIATION.
Oct. 12-14. Annual convention at Louisville, Ky. Secy., C. C. Rosenberg, Bethlehem, Pa.

AMERICAN RAILWAY BRIDGE AND BUILDING ASSOCIATION.
Oct. 19. Annual convention at Jacksonville, Fla. Secy., S. F. Patterson, Boston & Maine R. R., Concord, N. H.

AMERICAN PUBLIC HEALTH ASSOCIATION.
Oct. 19-22. Annual convention at Richmond, Va. Secy., Chas. O. Probst, Columbus, Ohio.

AMERICAN GAS INSTITUTE.
Oct. 20. Annual meeting at Detroit, Mich. Secy., A. B. Beadle, 29 W. 39th St., New York City.

SPECIAL LIBRARIES ASSOCIATION.—This association was organized at the conference of the American Library Association held in July at Bretton Woods, N. H. It is expected to be the active channel for the rendering of mutual assistance among the various special libraries constituting its membership. Officers have been elected as follows: President, John C. Dana, Free Public Library, Newark, N. J.; Vice-President, Robt. H. Whitten, Librarian, Public Service Commission, New York, First District; Secretary and Treasurer, Anna Sears, Librarian, Merchants' Association of New York. The first annual meeting will be held at the rooms of the Merchants' Association of New York for the purpose of perfecting the organization and determining the detailed methods for the association's work.